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**FINAL SITE  
INVESTIGATION REPORT  
INDUSTRIAL TRANSFORMER SUPERFUND SITE**

**Prepared in Cooperation with  
Texas Water Commission  
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EXECUTIVE SUMMARY  
REMEDIAL INVESTIGATION  
INDUSTRIAL TRANSFORMER SUPERFUND SITE  
HOUSTON, TEXAS

Introduction

Radian Corporation is under contract to the Texas Water Commission (TWC) to perform a Remedial Investigation (RI)/Feasibility Study (FS) at the Industrial Transformer Superfund (ITS) site. The work is being financed through Cooperative Agreement No. V-0066416-12 between the U.S. Environmental Protection Agency (EPA), and the Texas Water Commission (TWC). The RI/FS contract was executed June 30, 1986, and Amendment No. 1 to the contract was executed on October 28, 1987. Amendment No. 1 authorizes Phase II work which includes further remedial investigation and a feasibility study at the ITS site.

The objective of the RI/FS is to assess the nature, degree and extent of contamination at the ITS site, and to identify and evaluate remedial solutions to the contamination. Site sampling and investigation activities were performed from January 1987 to March 1987 and additional site investigation work is planned for the first quarter, calendar year 1988. The purpose of this report is to document the results of the remedial investigation portion of the study completed through December 1987.

A separate Quality Assurance/Quality Control (QA/QC) report presents the quality control data used to determine precision and accuracy of the data and documents the control of data quality to acceptable limits.

Background

The ITS site is located less than a mile east of the Astrodome/Astro-world complex on South Loop 610 West, inside the City of Houston. Access to the ITS site is gained by the freeway access road to the north, Knight Street to the west, Mansard Road to the south and South David Street to the east.

The site area is a mix of residential, commercial and light industrial facilities. Within a one-mile radius, a light industrial/commercial business area is located most closely to the site, then the recreational complexes of Astroworld and Astrodome, and finally a mix of private, single and multi-family dwellings further away from the site. The residential population is about 2,000, and a maximum daily traffic of 100,000 persons may move within the 1-mile radius due to recreational activities associated with the Astrodome and Astroworld.

As early as 1971, an unincorporated company, the Industrial Transformer Company, owned and operated by Mr. Sol Lynn, was located at this site. A City of Houston inspector noticed that workers at the company poured oil out of electrical transformers onto the ground as the transformers were dismantled. In the fall of 1971, Mr. Lynn was given a series of 7-day notices to confine oil and grease to his property. Subsequent inspections revealed no corrective action at the site. On September 11, 1972, the State of Texas brought suit against Mr. Lynn, on charges of illegally discharging industrial waste into Braes Bayou. Mr. Lynn was ordered to pay a \$100 fine.

In the fall of 1981, a City of Houston work crew noted strong chemical odors while installing a waterline adjacent to the Industrial Transformer Company. This property is also owned by Mr. Lynn, but at that time was leased to Mr. Ken James, owner of Sila-King, a reputed chemical-supply house. An inspection later that day by representatives of both the TWC and the City of Houston Department of Health showed about 75 empty drums scattered about on the property at 1415, 1417 and 1419 South Loop West. Most of the drums, labeled trichloroethene, were empty and had puncture holes.

Various regulatory agencies and the property owner collected a total of 101 soil samples, of which 47 were analyzed for trichloroethene (TCE) and 54 for polychlorinated biphenyls (PCBs). Of the 25 water samples collected, 21 were analyzed for TCE and 4 for PCBs. Sample results are summarized in Table 1.

TABLE 1. SUMMARY OF SAMPLES COLLECTED BY  
OTHER REGULATORY AGENCIES AND RESULTS

<u>Sample Type</u>	<u>No. of Samples/Percentage*</u>	<u>Parameter</u>	<u>Range</u>
Soil	34/72%	TCE	0.04 - 2862.3 ppm
Soil	13/28%	TCE	None Detected
Soil	44/77%	PCBs	0.13 - 729.6 ppm
Soil	10/23%	PCBs	None Detected
Water	13/62%	TCE	<1.0 - 953 ppm
Water	12/38%	TCE	None Detected
Water	2/50%	PCBs	<1.0 ppm
Water	2/50%	PCBs	None Detected

\* Number of samples and the percentage that tested positive for the parameter listed.



The consultant for the remedial investigation phase, Radian Corporation, was selected on May 27, 1986. The RI/FS contract was executed on June 30, 1986. Amendment No. 1, authorizing Phase II which includes further investigation and the feasibility study at the ITS site was executed October 28, 1987. Field work as approved in the work plan was initiated on January 14, 1987.

#### Statement of Problem

PCBs and TCE are the principal known contaminants at the site and the EPA has classified TCE and PCBs as possible carcinogens. The major concern is that exposure to TCE and PCBs may impact human health and the environment. Potential exposure pathways include direct contact, surface water, groundwater and air.

The investigation of the ITS site has been divided into 3 steps:

**Step 1 Presampling activities include:**

- Review of previous investigative activities and results, data gaps and insufficiencies;
- Proposed responses and remedial technologies to clean up PCB and TCE contaminated surface and shallow subsurface soil (proposed responses and remedial technologies to clean up TCE contaminated deep soil and groundwater will be address in the RI Addendum resulting from Phase 2);
- An assessment of existing conditions at the site; and
- Preparation of work plans including the Health and Safety Plan, Quality Assurance/Quality Control Plan, Sampling Plan and Project Management Plan.

**Step 2 Field sampling activities include:**

- Collecting surface soils and sediment samples and analyzing them for PCBs, TCE, priority organic pollutants (POP) and dioxins;
- Collecting soil samples from shallow boreholes (0-4 foot depth) and analyzing them for PCBs, TCE, POP and dioxins;
- Collecting soil samples from deep soil boreholes (39 foot depth) and analyzing them for PCBs, TCE, POP and dioxins;
- Converting deep soil boreholes into groundwater monitor wells, which are completed in the uppermost water-bearing zone;

- Collecting soil samples from additional monitor well (38-48.5 foot depth) installation program and analyzing them for PCBs, TCE, and POP;
- Collecting soil samples from intermediate monitor well (99 foot depth) underlying the uppermost water-bearing sand and analyzing them for PCBs, TCE, and POP;
- Completing monitor well (99 foot depth) in the next lower ("intermediate") water-bearing sand;
- Geotechnical testing of soil samples (sieve analysis, Atterberg limits);
- Completing a water well inventory of wells in a one-mile radius of the site;
- Measuring static water levels in all wells and determining hydraulic gradients;
- Collecting surface water samples (water in the ditch and water ponded on-site) and analyzing them for PCBs, TCE, and POP;
- Collecting groundwater samples from the uppermost and the intermediate water-bearing sands and analyzing them for TCE and volatile priority organic pollutants (VPOP); and
- Collecting air monitoring samples and analyzing them for particulates and PCBs.

Step 3 Site characterization/analyses include:

- Site geology and hydrology;
- Site features, including demography, land use, soils, natural resources and climatology;
- Nature and extent of contamination and concentration levels;
- Volume of contaminated soils and water;
- Contaminant pathways and rates;
- Target receptors;
- Potential impact of the known contamination on public health and environment; and
- Gathering of data sufficient to evaluate potential remedial activities.

Regional Setting

The two major aquifers underlying the site are the Chicot and, underlying it, the Evangeline. Because of the type of depositional setting that is inferred for the uppermost water-bearing unit, a crevasse-splay, there appears to be no natural hydrologic communication with the regional water-bearing units of the Chicot aquifer in the immediate area of the site.

Groundwater withdrawals by the City of Houston over a period of many years have led to decreases in the water levels in the regional aquifers. In the site vicinity, the Chicot has declined about 15 feet while the underlying Evangeline has also decreased about 25 feet in the period 1975-1980. Groundwater pumping has resulted in ground subsidence. Around the site locality, subsidence has averaged about 0.166 feet/year in the period 1963-1974.

Although growth faults or faults resulting from the upward movement of salt domes are common along the Gulf Coast, no faults or lineations are known to exist in the immediate vicinity of the site.

#### Site Characteristics

Soils at the site and in the vicinity are of the Lake Charles series, characterized by somewhat poor drainage and high available water capacity. When the soil is dry, deep, wide cracks form on the surface where water can enter rapidly. When the soil is wet, the cracks are sealed and water infiltrates slowly.

The site is located on the Beaumont Clay, of Pleistocene age. The lithology is comprised of unconsolidated clays and muds or deposits of clayey sands and silts. The depositional setting for the clays and muds include interdistributary, abandoned channel fill, overbank fluvial or mud-filled coastal lake or, tidal creek environments. The sands and silts record alluvium, levee and crevasse splay depositional environments.

The site stratigraphy consists of clays, extending from the surface down to the uppermost aquifer, the top of which ranges from 30 to 34 feet below the ground surface. A thin, 2 to 3 foot thick layer of silty, sandy clay interrupts the uppermost clay at about 18 to 21 feet of depth across the east portion of the site. At approximately 21 feet, the lithology returns to clay, extending to the uppermost water-bearing sand. The water-bearing sand varies in thickness from 2 to 6 feet, averaging 4.5 feet. Sand content increases from

west to east across the site, from 50% to 70%. This sand was probably deposited as the result of a levee or crevasse splay from a nearby Pleistocene fluvial channel and as a consequence, is probably localized.

The uppermost water-bearing sand is separated from the next lower, "intermediate" water-bearing sand by a stiff clay, approximately 45 to 52 feet in thickness. The intermediate water-bearing sand is also underlain by clay.

Surface drainage around the site includes shallow ditches that border the site along Knight and Mansard Streets. These two ditches carry surface run-off by slightly different routes to Braes Bayou, empties first into Buffalo Bayou then into the San Jacinto River Basin, and finally into Galveston Bay.

Regarding flooding, the site itself lies outside the 100-year flood plain.

#### Field Investigation Program

A program of water, soil, and sediment sampling was completed by Radian to identify the lateral and vertical extent, concentration level and volume of contaminants. Table 2 summarizes sample types and values of PCBs and TCE.

A total of 43\* surficial soil and six sediment samples was collected and analyzed for PCBs. Values ranged from 0.08 to 220 ppm. The three surficial soil samples containing the highest values of PCBs were then analyzed for dioxins, of which none was detected. A fourth sample was chosen for dioxin analyses from the shallow borings. Four surficial soil samples were chosen for TCE analysis, based on their proximity to known locations of TCE-contaminated soil. Values ranged from 0.0051 to 150 ppm. One sediment sample out of six was chosen for POP analysis. Results of the POP analysis confirm the presence of TCE.

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\*Two surficial soil samples (Nos. 1 and 27) exceeded laboratory holding times for analysis. Data from these samples are not presented in the RI but are discussed in the Quality Assurance/Quality Control report.

TABLE 2. SUMMARY OF SAMPLE TYPES AND RESULTS

Sample	Sample Type	No.	Parameter	Range (ppm)**	Comments
Soil & Sediment	Soil	51	PCB	0.08-220	
		4	TCE	0.02 - 2	
		1	POP		TCE:0.0018
		3	Dioxin		None Detected
Shallow Soil Boring	Soil	37	PCB	0.05-137	
		18	TCE	0.0051-150	
		4	POP		TCE:0.003-57
		1	Dioxin		None Detected
Deep Soil Boring	Soil	50	PCB	0.08-350*	
		4	TCE	0.0077-43	
		1	POP		TCE:240
Monitor Well	Soil	16	PCB	0.05-2	
		4	TCE	15-2000	
		1	POP		TCE:12
Groundwater	Water	15	TCE	0.0007-500	
		4	VPOP	1.5-320	
Stormwater	Water	7	PCB	0.17	
		2	POP		TCE:0.0026
Ambient Air	Air	6	Particles	22-123ug/m <sup>3</sup>	
			PCB		None Detected

Key: PCB - polychlorinated biphenyls  
TCE - trichloroethene  
POP - priority organic pollutants  
VPOP - volatile priority organic pollutants

\* The highest value, 350 ppm, was observed in the uppermost foot.

\*\* Values have been rounded.

The shallow boring program (0 to 4 feet depth) consisted of 19 shallow boreholes. In seventeen of these boreholes, two samples were collected, one from the 0 to 2 feet depth and the other sample from the 2 to 4 feet depth. A composite sample (No. 37) was collected from the last shallow borehole.

The eighteenth shallow borehole has valid data from the 2-4 foot depth. The sample from the 0 to 2 foot depth of borehole 12 exceeded laboratory holding times for analyses and is not presented here. The QA/QC report discusses this data in detail.

All 37 samples from the shallow boreholes were analyzed for PCBs. Values ranged from 0.05 to 220 ppm. An HNu analyzer was used to screen samples for volatile organic vapors and those samples with positive readings were selected for TCE analysis. Several other samples that did not have a positive HNu reading were selected for analysis as well, based on their proximity to known locations of TCE-contaminated soils. TCE values range from 0.0051 to 150 ppm.

Four samples from shallow boreholes were selected for POP analysis, based on a positive response to the HNu analyzer or location to previously known locations of TCE contamination.

One shallow borehole sample was analyzed for dioxins as well as three surficial soil samples. No dioxins were detected.

A total of 50 soil samples were collected from five deep soil boreholes for PCB analysis. PCB values ranged from 0.05 to 350 ppm. Four soil samples were analyzed for TCE, based on a positive HNu analyzer response. TCE values ranged from 0.0077 to 43 ppm. One sample was analyzed for POP analysis, which indicated TCE was present.

Sixteen soil samples were collected for PCB analysis from two of the seven monitor wells that were not converted from deep boreholes. Values ranged from none detected to 1.3 ppm\*. Four soil samples were analyzed for TCE, based on positive HNu analyzer results. TCE values range from 15 to 2000 ppm. One sample selected for POP analysis indicated the presence of TCE.

Nine samples were analyzed for various geotechnical parameters. Grain size analyses were conducted on the samples from the uppermost and intermediate water-bearing sands. The uppermost zone contains increasing amounts of fine sand, 50% to 70%, from west to east across the site. The other portions of the samples consist of fine silts and clays. The intermediate water-bearing zone is composed of 50% fine sand and 50% fine silts and clays.

A total of seven groundwater monitor wells were installed, six in the uppermost water-bearing zone and one in the intermediate water-bearing sand.

Four complete sets and one incomplete set of water level measurements were performed on all wells to define the site-potentiometric surface and to define the direction and hydraulic gradient of groundwater flow. A north-north-westerly flow was established for the uppermost water-bearing sand. The observed gradients range from 0.0030 ft/ft to 0.0036 ft/ft. Static water level averages 3 to 4 feet below ground level for the shallow wells. Static water level in the intermediate well averages about 25.68 feet below ground level. The significant difference in the potentiometric level indicates little or no hydraulic connection between the two zones in the immediate area of the site.

Hydraulic conductivity (K) data for the uppermost water-bearing zone ranges from 0.63 to 2.03 feet/day. The hydraulic conductivity differs because of variations in porosity, grain size, shape, sorting and packing. The variations observed within the shallow aquifer are within expected ranges. The hydraulic conductivity for the intermediate zone has been computed to be 0.029 feet/day. Transmissivity is a function of hydraulic conductivity and thus follows the same patterns as hydraulic conductivity.

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\*Monitor well samples MW-3/S-1, MW-3/S-2, and MW-3/S-3 exceeded laboratory holding times, and therefore, these results are not presented in this report. The QA/QC report presents this data in more detail.

Water samples were collected twice from the uppermost water-bearing zone and analyzed for TCE. Even though individual values varied between the first and second rounds for a given well, the overall ranking of wells in terms of concentration of TCE remained the same in both rounds. In the shallow aquifer, highest concentrations (for both rounds) have been observed in MW-2 (430 ppm and 500 ppm for rounds 1 and 2, respectively) followed by MW-4 (250 ppm/400 ppm), then MW-5 (190 ppm/300 ppm). The other 3 wells have considerably lower values: MW-7 (46 ppm/72 ppm), MW-6 (25 ppm/26 ppm), and lastly, MW-1 (0.003 ppm/0.007 ppm) (Figures 1 and 2). All six wells showed consistently higher values in the 2nd round of sampling compared to the first.

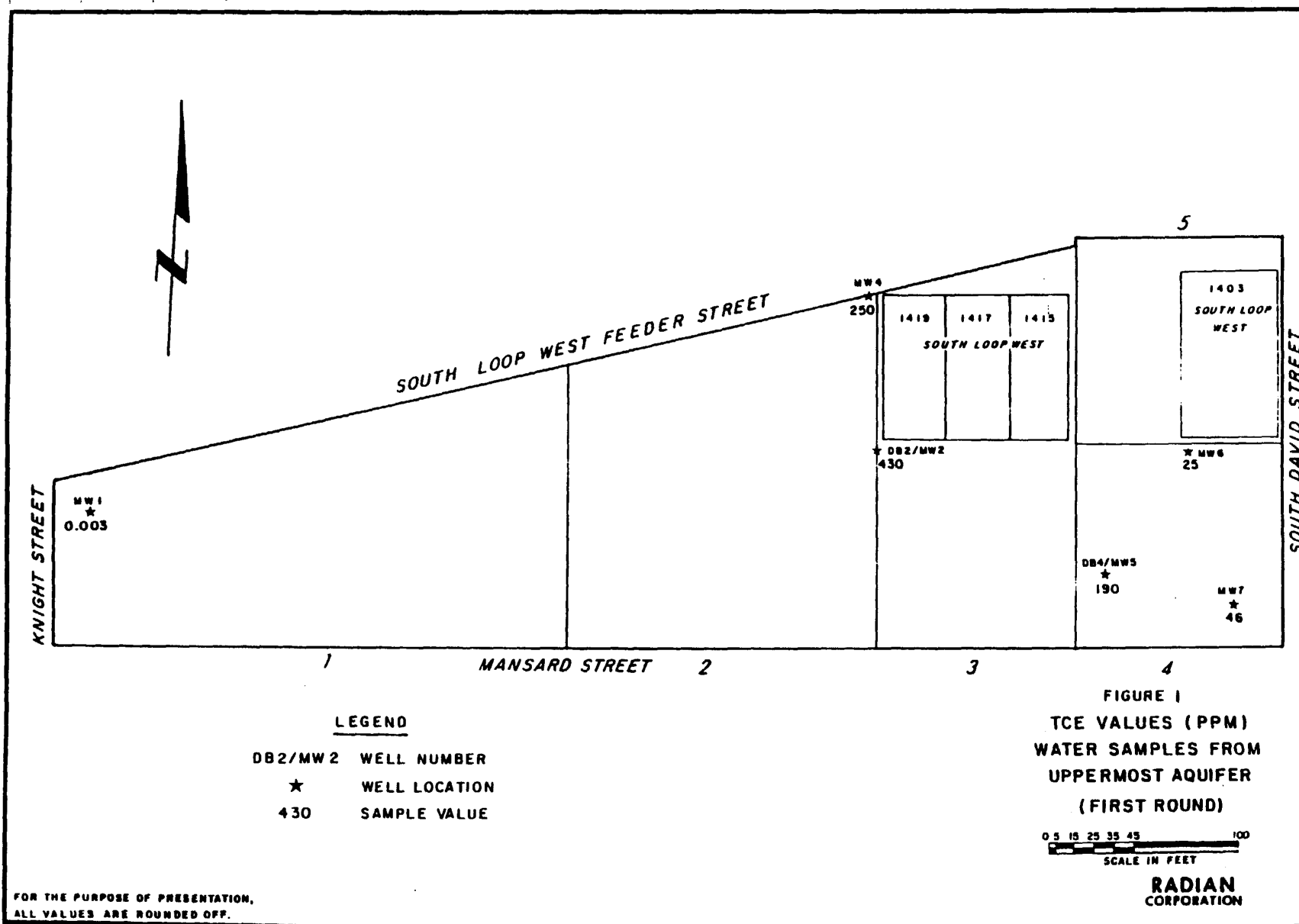
MW-3, completed in the intermediate zone, was sampled and analyzed three times. TCE values for Rounds 1, 2, and 3 respectively were 26 ppm, 2.1 ppm, and 0.12 ppm; however, the last two values are of questionable accuracy due to problems in the well.

Volatile priority organic pollutant analysis (VPOP) identified TCE as the contaminant present in the groundwater monitor wells. The comparative ranking remains the same between the wells, with MW-2 reporting the highest amount of TCE, 320 ppm; MW-4 reporting 310 ppm; and MW-5 reporting 190 ppm. No other compounds were detected.

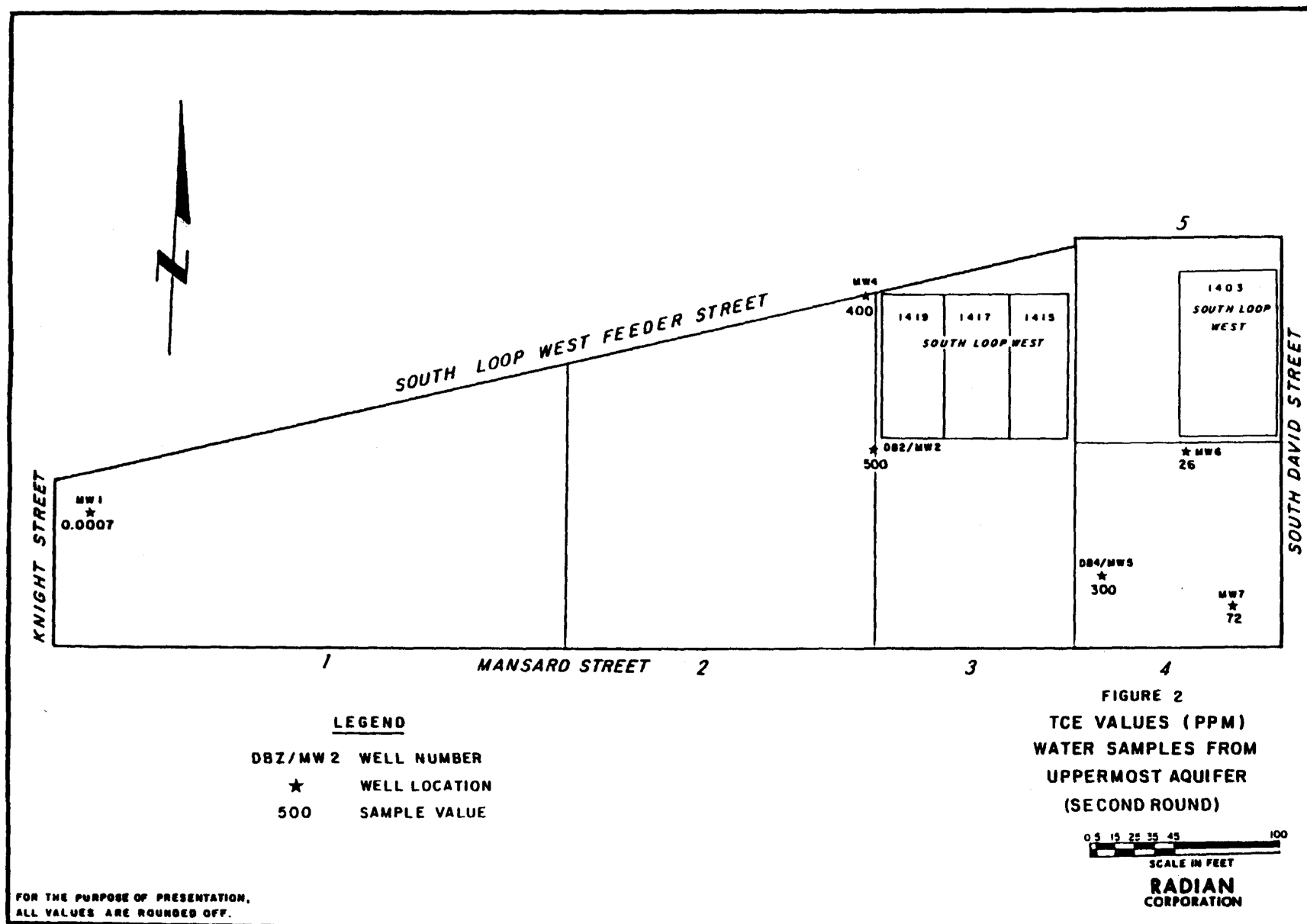
The highest TCE concentrations have been observed at MW-2. A review of the groundwater gradient and the observation of TCE concentrations indicate the plume did not originate at MW-2, since upgradient wells show significant concentrations of TCE. There are several possible explanations: reversal of groundwater gradient over time or several scattered sources of TCE contamination at or close to the surface which have vertically migrated down to the uppermost water-bearing zone.

Stormwater sample analyses report that only one of seven samples contained PCBs (0.17 ppm), indicating the low potential for contaminant migration off-site via surface run-off under the present conditions. The POP





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analysis reported the presence of TCE and phenol, another organic constituent, at a sample location downstream of run-off from the ITS site.

Low PCB values are reported in the sediment samples at less than 5 ppm each, with the exception of one sample that contained 47 ppm. This finding indicates that PCBs may have migrated from the site to off-site areas during past run-off events. However, the lack of a background sample does not conclusively prove the existence of contaminant migration from the site.

All air filter samples were analyzed for total particulates and four filters were analyzed for PCBs. No PCBs were detected on any of the filters. Total suspended particulates (TSP) concentration ranged from 22 to 54 to 78 ug/m<sup>3</sup> upwind of the site and from 43 to 53 to 123 ug/m<sup>3</sup> downwind of the site. The amount of particulates accumulated in the upwind and downwind filters does not provide conclusive evidence of significant contribution of particulates to the atmosphere from the ITS site.

#### Public Health Effects

TCE is one of two major contaminants at the ITS site. It has been classified by the EPA as a probable human carcinogen. Pathways of exposure to TCE include ingestion (soil or drinking water), inhalation, and dermal exposure, of which the first two pathways pose significant public health concerns. Soil containing greater than 161 ppm TCE may pose health hazards when ingested or inhaled. This criteria is based on a public health assessment. However, no surface soil samples at the ITS site contain more than 2 ppm TCE. The acute, short-term exposure from TCE found in the subsurface does not exceed the 50 ppm Threshold Limit Value (TLV) set by the American Council of Government Industrial Hygienists (ACGIH).

The second of the two major contaminants is PCBs, an organic compound classified by the EPA as a suspected carcinogen in humans. This organic compound is resistant to degradation and is capable of bioaccumulation and bioconcentration in the fatty tissue of organisms. PCBs may also be associated

with mutagenicity and teratogenicity. PCBs may pose risks to public health through ingestion of soil or drinking water, inhalation, and dermal exposure. Ingestion and inhalation pose the major pathways of exposure to PCBs because of the site's location in a light industrial/commercial area with little foot traffic. Results of air sampling report no PCBs were contained on airborne soil or dust particles. There are negligible health risks posed by the drinking water route because PCBs typically adsorb to soil particles and are relatively insoluble in water.

The Toxic Substances Control Act (TSCA) governs the manufacture, sale, distribution, and disposal of PCBs. TSCA requires spilled PCBs to be remediated to different levels, depending on factors such as:

- Spill location,
- Potential for exposure to residual PCBs remaining after remediation,
- Initial concentration of spilled PCBs, and
- Nature and size of the population potentially at risk of exposure.

A remediation effort resulting in PCB levels in the soil of 25 ppm or less results in a less than  $1 \times 10^{-7}$  level of cancer risk to people on-site who work more than 0.1 km from the actual spill site, assuming that the spill area is less than 0.5 acre.

The ITS site varies slightly from those characteristics listed in TSCA policy in the following manner:

- Light industrial/commercial activities are in operation within 0.1 km of the site, including rental of office/warehouse space on-site; and
- The spill covers an area of about 0.71 acre.

The EPA, Region 6, has set a cleanup policy for the site commensurate with an industrial-setting at 25 ppm PCBs. Figure 3 shows samples exhibiting PCB concentrations greater than 25 ppm. All available data show that PCBs of 25 ppm or greater are limited to the upper two feet of soil. A risk calculation shows the excess risk of cancer from ingesting soils containing 350 ppm PCBs is approximately 1 out of 1500.

#### Volume of Contaminated Soil

PCBs, which cover a larger area than TCE, act as the driving force determining the area of remediation. The area to be remediated also includes that contaminated by TCE and contains approximately 3,422 square yards (Figure 4). Remediation to a depth of 2 feet involves a volume of 2,281 cubic yards.\*

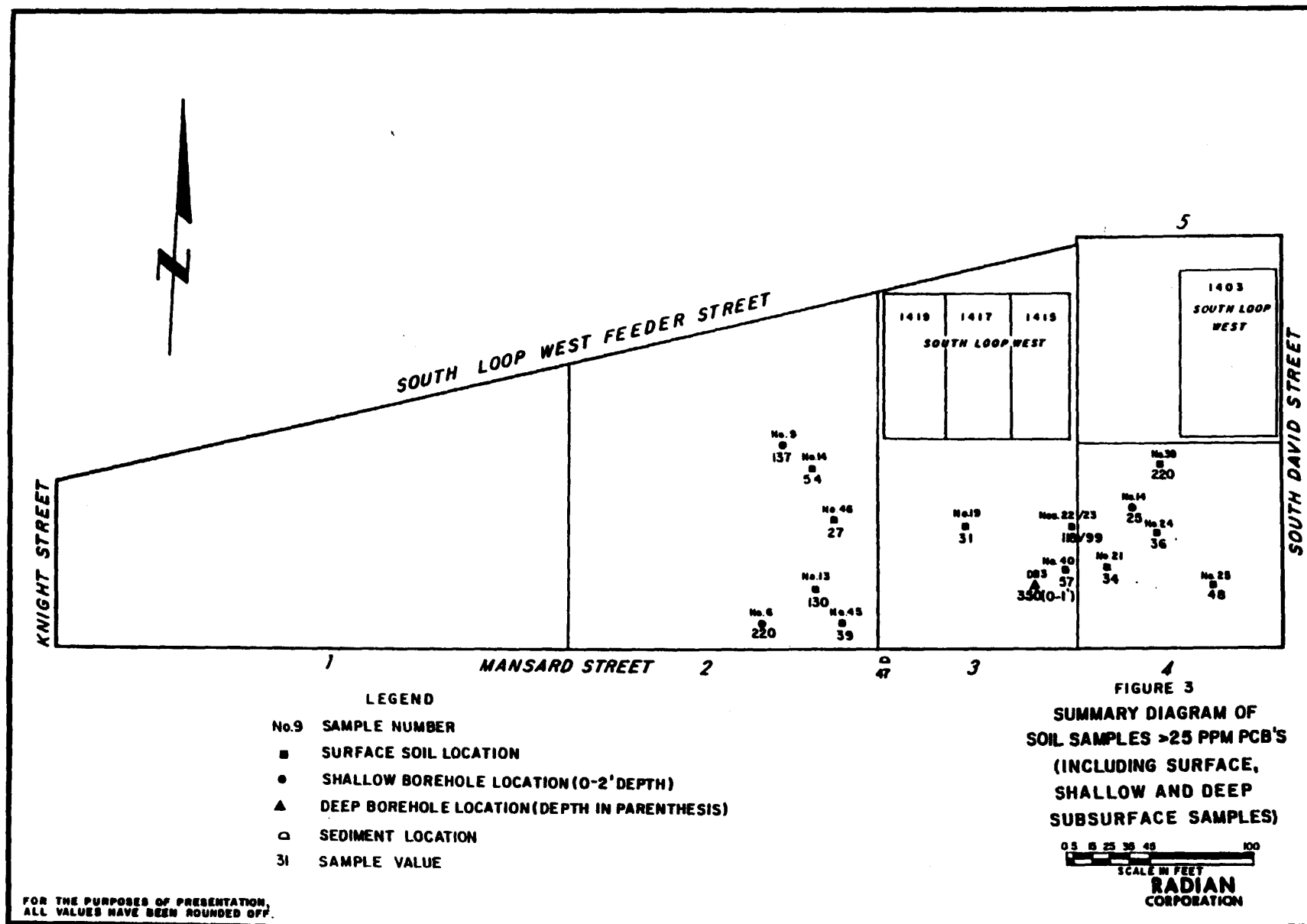
#### Future Work

Further investigation of deep subsurface soils and the intermediate water-bearing unit are being planned for Phase II. Such investigations are based on the discovery of TCE in soil at depth. Using MW-3 as an example, 390 ppm TCE was found at 9-10 feet depth, 75 ppm at 25-26 feet depth, 110 ppm at 54-55.5 feet depth and 15 ppm at 89-90.5 feet depth. TCE discoveries in the soil of four other monitor wells and deep boreholes confirm its presence in the upper clay, the uppermost water-bearing unit, the intermediate clay and intermediate water-bearing unit. Field work will start in the first quarter of calendar year 1988 and will involve the collection of 30 soil cores and analyses for TCE contamination from the clay unit underlying the uppermost water-bearing sand where three monitor wells will be installed. These wells will be completed in the intermediate water-bearing zone.

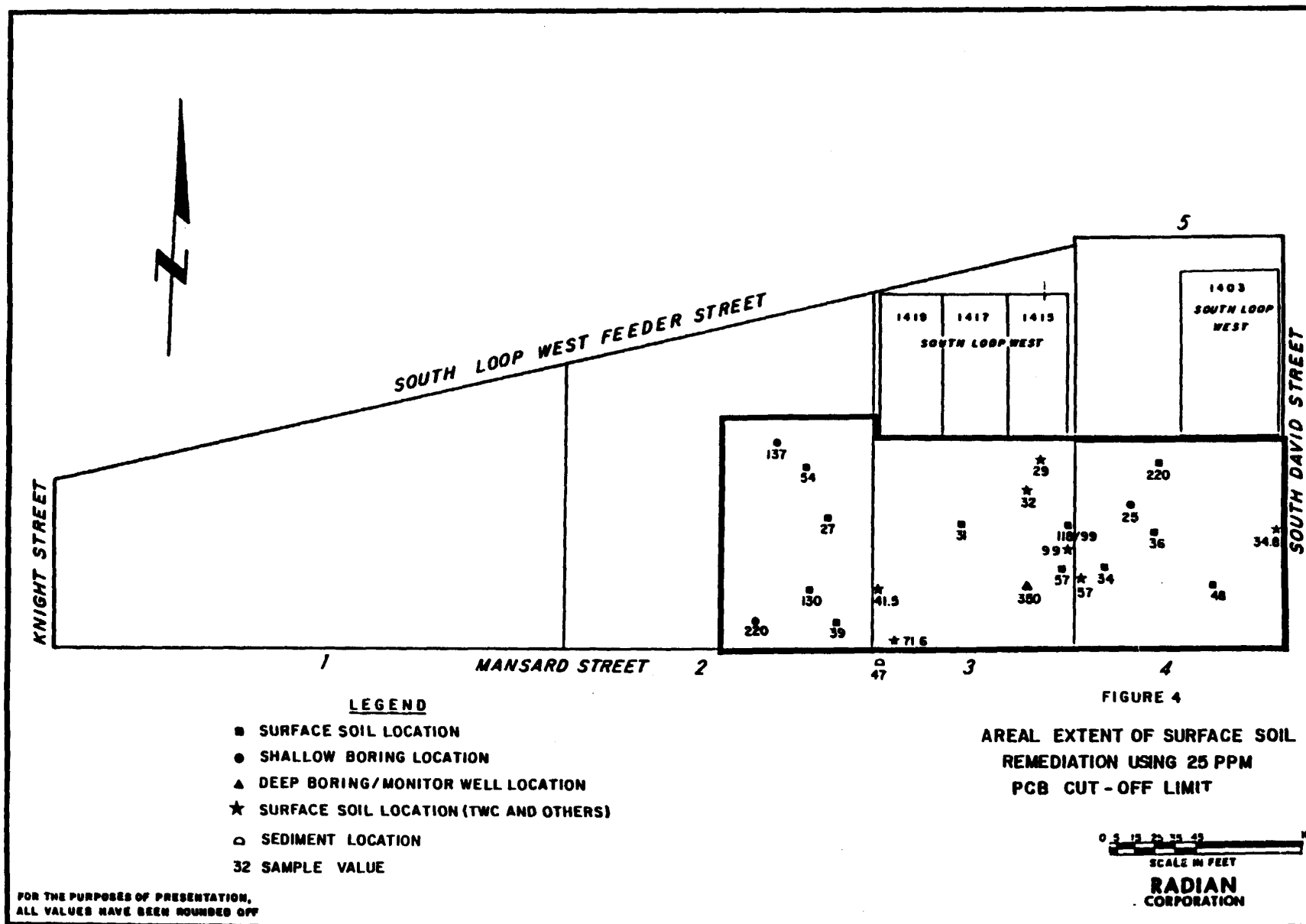
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\* The surface area and volume of soils requiring remediation have been rounded up for presentation in the FS to account for hot spots. The area and accompanying volume requiring remediation are listed respectively in the FS as 0.75 acres and 2480 cubic yards.

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The presence of TCE in all the water samples (0.0007 to 500 ppm) from the uppermost water-bearing unit and indications of its presence (0.12 to 26 ppm) in the water samples from the intermediate water-bearing unit provide the justification for further water collection and analyses in the Phase II investigation.

Two rounds of water samples will be collected from all nine wells for a total of eighteen samples. These will be analyzed for TCE. Cone-pentrometer work will be conducted to define the extent and magnitude of the TCE contaminant plume. Cone penetrations will also be used at off-site locations to collect 20 water samples which will be analyzed for TCE.

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SECTION 1  
INTRODUCTION

Radian Corporation is under contract to the Texas Water Commission (TWC)\* to perform a Remedial Investigation (RI) /Feasibility Study (FS) for the Industrial Transformer Superfund (ITS) site. The work is being performed through Cooperative Agreement No. V-006416-12 between the U.S. Environmental Protection Agency (EPA) and the TWC. The RI/FS contract was executed June 30, 1986 and Amendment No. 1 to the contract was executed on October 28, 1987. Amendment No. 1 authorizes Phase II work which includes further remedial investigation and a feasibility study at the ITS site.

The field work associated with the remedial investigation was performed in January and February, 1987. Based upon the results of the initial investigation, a second phase (Phase II) of field investigation is planned for the first quarter of calendar year 1988. This report presents the findings of the RI completed to date (July, 1987). Also, included in this report is a discussion of the nature and extent of contamination resulting from past activities at the site as evident from the data gathered during the RI.

A separate Quality Assurance/Quality Control (QA/QC) report presents the quality control data used to determine precision and accuracy and documents the control of data quality to acceptable limits.

The objectives of the remedial investigation are to assess public health and environmental health risks posed by the site and to identify remedial solutions. In view of these objectives, the work completed during the RI in general terms includes:

- A review of background data;
- A site investigation including sampling and analysis of sediments, soils, surface and subsurface waters;

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\* Before September 1, 1985, the Texas Water Commission was known as the Texas Department of Water Resources and predating that, the Texas Water Quality Board. To simplify terminology in this report, the Texas Water Commission will refer to the present agency as well as its predecessors.

- An evaluation of environmental and public health concerns; and
- Gathering of the required data inputs for the FS in which remedial action alternatives are developed and evaluated.

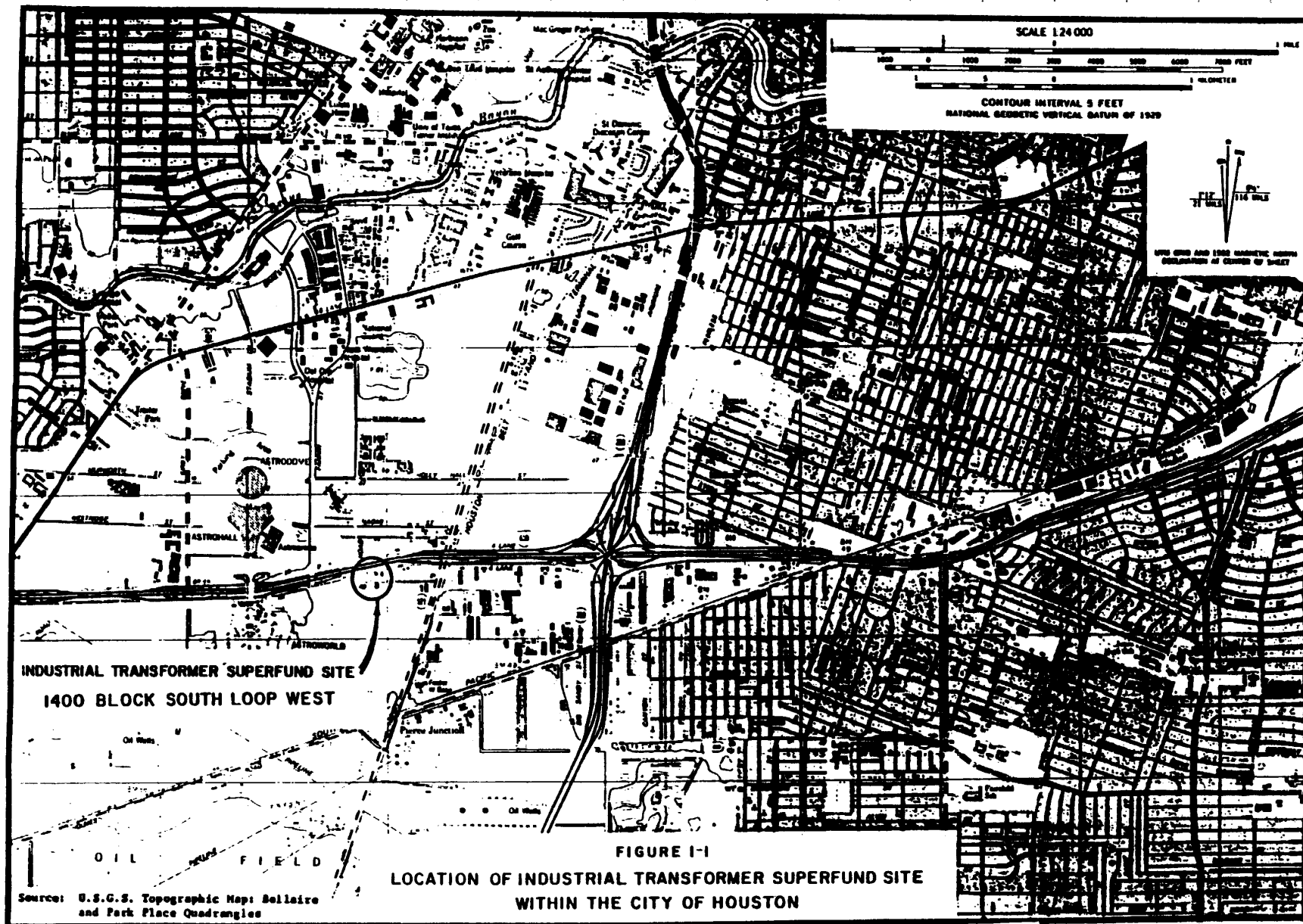
The RI/FS at the ITS site is being performed as a CERCLA or Superfund project following evaluation by the Hazard Ranking System and inclusion on the National Priority List (NPL). CERCLA is an acronym for Comprehensive Environmental Response, Compensation and Liability Act, more popularly known as "Superfund". It was enacted in 1980 to remediate hazardous substances at uncontrolled or abandoned hazardous waste sites and to provide funding and procedures for the federal government together with state governments, to ensure remediation of hazardous substance locations, whether a responsible party has been identified or not.

The Superfund Amendments and Reauthorization Act (SARA), a five-year extension of CERCLA, was signed into law October 17, 1986. SARA provides a number of additions to existing law but among the most important are:

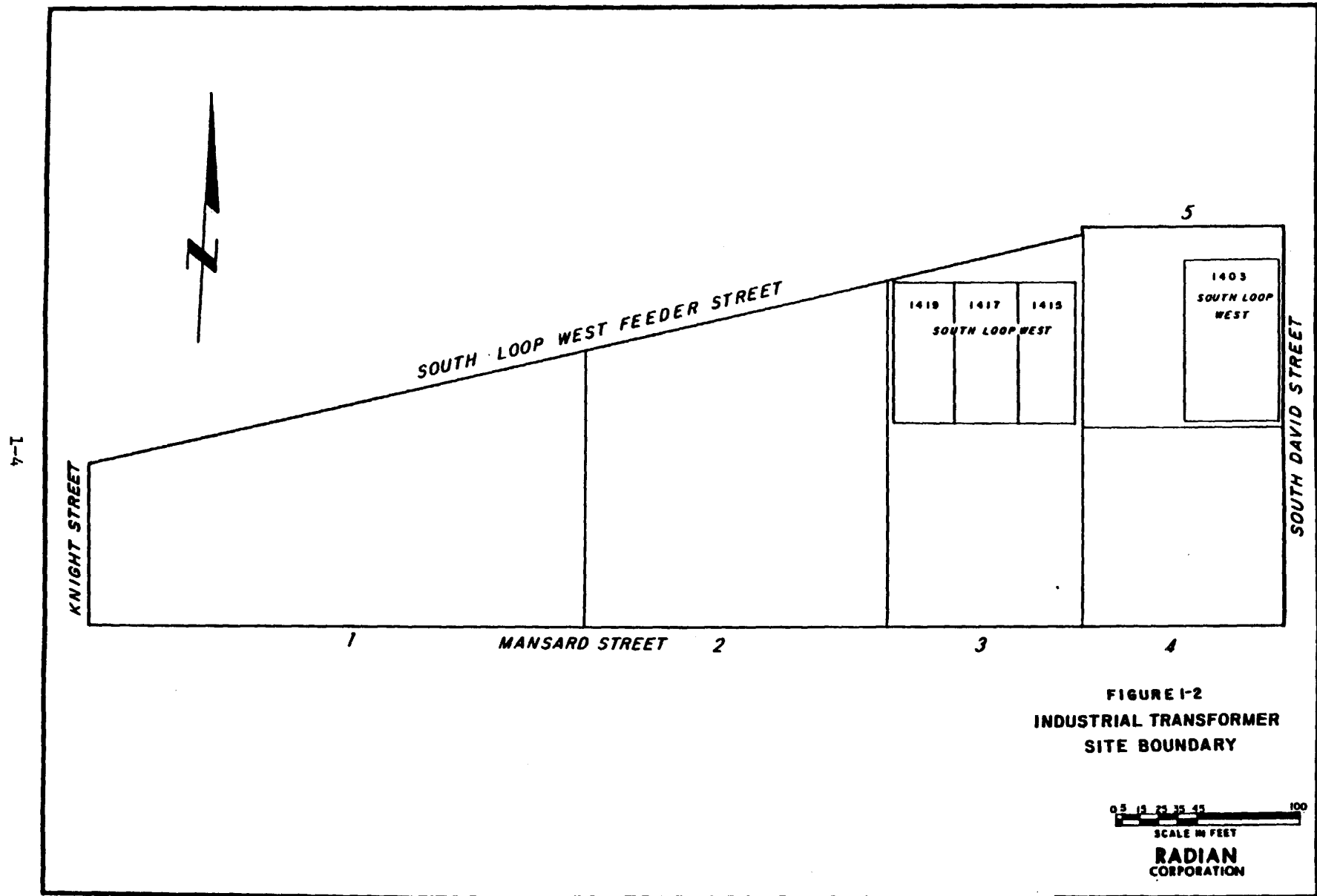
- New emphasis is placed on risk reduction, using techniques that allow destruction/detoxification of waste, rather than preventing exposure. More pointedly, permanent solutions and treatment to permanently and significantly reduce the toxicity, mobility and/or volume of hazardous substances are preferred.
- Remediation must attain Federal applicable or relevant and appropriate requirements (ARARs) and more stringent State ARARs.

#### 1.1 SITE DEFINITION

Figure 1-1, taken from the U.S. Geological Survey Topographic Map, Bellaire and Park Place Quadrangles, shows the ITS site and areas surrounding this site. The specific lots and other contiguous lots within this block of land which is bounded by Knight Street on the west, Mansard Street to the south, South David Street to the east and the I-610 (South Loop West) feeder road to the north are described in Appendix A-1. Appendix A-1 also lists the legal description of these properties and illustrates their location. Figure 1-2 provides a more detailed presentation of the site.



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For the purpose of ease in referencing and discussions, the block of land bounded by the above named streets has been informally divided into five areas (Figure 1-2). As depicted on Figure 1-2, Areas 1 and 2 are vacant land on the west part of the site, while the north half of Area 3 is occupied by a metal building (1415, 1417, and 1419 South Loop West addresses). The south half of Area 3 is a parking lot. Area 4 lies on the eastern edge of the site and is vacant. A metal building formerly occupied by Con-Equipment is situated on Area 5, 1403 South Loop West. All subsequent discussions will refer to these specific areas.

## 1.2 SITE HISTORY

As early as 1971, an unincorporated company, the Industrial Transformer Company, owned and operated by Mr. Sol Lynn, was located at this site. The first documented investigation of this site took place in the fall of 1971<sup>(1)</sup>. The City of Houston Water Pollution Control Division noted that the workers at the Industrial Transformer Company poured oil out of electrical transformers onto the ground as the transformers were dismantled. Soil contaminated with oil and grease was noted. Oil and grease were observed floating on the ponded water on the property and in the ditch adjacent to the property. Neither soil nor water samples were obtained. Mr. Lynn was given a 7-day notice to confine oil and grease to his property. Subsequently, a 14-day notice was issued on October 1, 1971 and a 7-day notice was issued on October 20, 1971 for the same subject matter. Continuing inspections revealed no corrective action at the site.<sup>(2)</sup> On January 7, 1972, the City of Houston Water Pollution Control Division requested Mr. Lynn to discontinue dumping of transformer cooling oil on the property, to clear or dike-off existing oil and oil-saturated soil so as to eliminate run-off from this property and to correct improper sewage disposal<sup>(3)</sup>. On September 11, 1972, the State of Texas brought suit against Mr. Lynn, on charges of illegally discharging industrial waste into Braes Bayou.<sup>(4)</sup> On November 13, 1973, Mr. Lynn was ordered to pay a \$100 fine.

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(1) Footnote: Because of an excessive number of footnotes in this section, they have been compiled and presented in Appendix A-2.

An inspection of the Industrial Transformer Company site on November 10, 1978 by a field representative of TWC showed no evidence of oil spills or unauthorized discharges from either the warehouse or the adjoining lot.<sup>(5)</sup>

On January 13, 1980, a representative of TWC observed some old drums stored behind Sila-King, Inc., a chemical supply company operating at 1419 South Loop West. An oily discharge was observed from a drum storage area behind the warehouses. Also, oil stains were observed on soil. In a subsequent telephone conversation on January 24, 1980, Mr. Ken James, owner of Sila-King explained that Sila-King was a chemical supply house, selling miscellaneous chemicals to industries. It was also reported that Sila-King bought old drums from various facilities, some clean and some which may have contained soaps and solvents.<sup>(6)</sup> The warehouses at this location used by Sila-King, Inc. are owned by Mr. Lynn, who had operated Industrial Transformer Company previously at this location.<sup>(7)</sup> An analysis of water and soil samples taken by the City of Houston Department of Health on September 11, 1981 showed the major contaminant to be trichloroethene (TCE) (See Appendix A-3 and A-4).

On September 14, 1981, a City of Houston work crew noted strong chemical vapors while installing a waterline along the north ditch of Mansard Road, adjacent to the property owned by Mr. Lynn. The site was investigated the same day by representatives of TWC and the City of Houston Department of Health. A strong smell of TCE was noted. The inspection revealed that approximately 75 drums were scattered on the property owned by Mr. Lynn at 1415, 1417, and 1419 South Loop West. Most of the drums were labeled "trichloroethene" and were empty and punctured. A strong TCE odor was detected in tap well water at the 1417 South Loop West address.<sup>(8)</sup> At that time, a worker at an adjacent business stated to a TWC field representative that he had observed Mr. Lynn and another worker emptying drums on Mr. Lynn's property early in 1981.<sup>(9)</sup>

Between March 16 and March 29, 1982, the drums labeled trichloroethene disappeared from the property at 1415, 1417, and 1419 South Loop West.<sup>(10)</sup> Mr. Lynn was requested by a letter dated March 23, 1982 to provide a written

written response concerning his plans to remove the hazardous waste from soils and groundwater.<sup>(11)</sup> Mr. Lynn responded by phone (March 29, 1982) and stated that the chemical waste drums were the responsibility of a prior lessee, Sila-King, Inc., Mr. Ken James, President. He indicated that Sila-King had received drums of spent paint, solvent and weed killer and used this waste as raw material to produce carbon black.<sup>(12)</sup> Mr. Lynn, through his attorney, then responded in writing to the request by District 7, TWC, in which Mr. Lynn denied any responsibility and placed all blame on Mr. James.<sup>(13)</sup> Efforts made by the EPA and TWC to locate Mr. James, last reportedly residing in Las Cruces, New Mexico, were in vain.<sup>(14)</sup>

On February 29, 1984, the Solid Waste Enforcement Unit of TWC requested of the EPA that the Industrial Transformer Site be ranked for corrective action through the Superfund program.<sup>(15)</sup> The Hazard Ranking System Package for the ITS site was submitted to Region VI, U.S. EPA, with a score of 39.65 on April 16, 1984.

On May 24, 1984, the State of Texas and EPA filed suit<sup>(16)</sup> against Mr. Lynn, owner and operator of Industrial Transformer Company and owner of properties located at 1415, 1417 and 1419 South Loop West; and Mr. James, President of Sila-King, Inc.; and Sila-King, Inc., a Texas corporation. The suit stated that during the early 1970's, the Industrial Transformer Company operated on the site, reclaiming metals from electrical transformers and that during this period, Industrial Transformer Company, its employees or authorized agents allegedly spilled/dumped transformer oil containing polychlorinated biphenyls (PCBs) onto the ground at the site and into the adjacent drainage ditches. The same suit also alleged that during the period 1979-1980, when Sila-King leased and occupied facilities at 1419 South Loop West, it purportedly operated as a chemical supply house and bought used drums for resale. As a result of the operations, TCE, a listed hazardous waste, was allegedly released to the environment.

Table 1-1 lists a chronological summary of events (including sampling trips) related to the development of the ITS site as a Superfund project.

On January 7, 1986, the TWC issued the Request for Proposals (RFP). Selection of the consultant, Radian Corporation, occurred on May 27, 1986. The RI/FS contract was executed on June 30, 1986. Amendment No. 1, authorizing Phase II for further remedial investigation and the feasibility study at the ITS site was executed October 28, 1987. Radian Corporation then wrote a detailed work plan, including specifics of sampling, health and safety and QA/QC procedures. The work plan or "Scope of Work" was approved by the TWC and EPA on October 13, 1986. Field work as approved in the work plan was initiated on January 14, 1987.

### 1.3 STATEMENT OF PROBLEM

As evident from Section 1.2, PCBs and TCE are the principal contaminants at the site. The EPA has classified TCE and PCBs as possible carcinogens (Federal Register, Nov. 13, 1985). The major concern posed by contamination at the ITS site is that exposure to TCE and PCBs may impact human health and environment. Potential exposure pathways include direct contact, ingestion of surface water or groundwater, and inhalation. Contamination may potentially enter water supplies through two main pathways:

- Vertical migration to the underlying aquifer, and
- Horizontal migration to the surface waters via rainfall run-off.

Another concern is that contaminated soils may become airborne by wind erosion, spreading contamination and threatening exposure by inhalation.

Since 1981 and prior to initiation of this study, 24 discrete sampling events have been completed either by the TWC, the City of Houston, the



TABLE 1-1  
CHRONOLOGICAL SUMMARY OF EVENTS  
RELATED TO THE  
INDUSTRIAL TRANSFORMER SUPERFUND SITE

9/21/71 Investigation by City of Houston Water Pollution Control Division noted that workers at the Industrial Transformer Company poured oil out of electrical transformers in the process of being dismantled; investigator noted oil and grease on soil and floating in water on the property as well as in the ditches: 7 Day Notice to confine oil or grease to his property.

10/1/71 14 Day Notice, as above.

10/20/71 7 Day Notice, as above.

1/7/72 City of Houston Water Pollution Control Division requests Mr. Lynn to discontinue dumping of transformer cooling oil on the property, to clean up or dike off existing oil and oil-saturated soil so to eliminate run-off from this property and to correct improper sewage disposal.

9/11/72 State of Texas brought suit (to Harris County Criminal Court) against Mr. Lynn, on charges of illegally discharging industrial waste into Braes Bayou.

11/13/73 Mr. Lynn ordered to pay \$100 fine on charges of illegally discharging industrial waste into Braes Bayou.

11/10/78 Industrial Transformer Company was inspected by Karen Macko of District 7, TWC; no evidence of oil spills or unauthorized discharges from either the warehouse or adjoining lot.

1/23/80 Karen Macko, formerly of District 7 (Deer Park) and now of the TWC Central Office, reported that Sila-King, a chemical supply company, had some old drums stored behind its location at 1419 South Loop West, Houston. The warehouses at this location are owned by Mr. Lynn. Mr. Lynn had operated Industrial Transformer Company previously at this location.

9/11/81 A sample of water and dirt was collected by City of Houston staff from 1417 South Loop West. Analyses showed the major contaminant to be trichloroethene (TCE).

Note: For a complete listing of samples collected, collector's name and affiliation, chain-of-custody verification and data results, see Appendices A-3 and A-4. Only those sampling excursions pertinent to the development of Industrial Transformer Site as a CERCLA or "Superfund" project are listed here.

- 9/14/81 City crews noted that excavated soils on Mr. Lynn's property omitted strong chemical odors. Investigation by the City and TWC staff detected the odor of TCE. Seventy-five (75) drums were noted scattered about the property. Most drums were empty and punctured. Many drums were marked with trichloroethene labels. Tap water from the 1417 South Loop West location omitted a strong odor of TCE.
- 11/17/81 Fred Dalbey of TWC - District 7, collected a groundwater sample from Mr. Lynn's property in issue. Test results indicated TCE contamination of the water, thereby supporting the City's allegation that groundwater has been contaminated with TCE.
- 3/12/82 Fred Dalbey collected a tapwater (well-water) sample and two soil samples. The water sample analysis revealed TCE. Soil samples showed polychlorinated biphenyl (PCB) concentrations of 22.5 mg/kg and 24.7 mg/kg as well as TCE.
- 3/23/82 District 7 staff mailed a letter to Mr. Lynn requesting a written response concerning his plans to remove the hazardous waste from the soils and groundwater. Mr. Lynn was given until April 30, 1982 in which to respond.
- 3/29/82 Dalbey was phoned by Mr. Lynn, property owner, who stated that chemical waste drums were the responsibility of prior lessee Sila-King. Mr. Lynn said lessee received drums of spent paint solvent and weed killer. Property in question is at 1415, 1417, and 1419 South Loop West, Houston. Mr. Lynn had operated a company at this location known as Industrial Transformer Company. As early as January 7, 1972, City of Houston officials wrote to Mr. Lynn requesting that he discontinue dumping transformer oil on his property. There apparently was a run-off problem into nearby watercourses. He was also requested to remove standing oil and oil-saturated soils.
- 3/12/82 to 3/29/82 Drums labeled "trichloroethene" disappeared from property owned by Mr. Sol Lynn at 1415, 1417, 1419 South Loop West, in violation of RCRA regulations.
- 4/12/82 Mr. Lynn has also collected soil and water samples for analysis but the date of collection is unknown. On April 12, Herman Kresso of MBA Laboratories phoned Dalbey to report the test results: TCE was found in both samples.
- 4/16/82 Dalbey collected more samples of soils from the 1415, 1417, and 1419 South Loop West warehouse area owned by Mr. Lynn. All three samples showed contamination by PCBs and TCE.
- 4/23/82 Mr. Lynn's attorney, Clark G. Thompson, responded to the District 7 letter. Mr. Lynn denies any responsibility/guilt for the contamination. All blame for the problem is placed upon a Mr. Ken James, now of Las Cruces, New Mexico.

000873

9/15/82 During an inspection on this date, Mr. Jim Jaoregny of Con-Equip stated that he had seen Mr. Lynn and a worker emptying drums on Mr. Lynn's property in issue early in 1981.

10/13/82 TWC sent letter to Mr. Lynn requesting his attendance at a meeting with representatives of TWC to discuss clean-up of the site.

11/16/82 Mr. Clark G. Thompson, attorney for Mr. Lynn, called to say they could not make it to the meeting.

12/3/82 Dalbey collected water samples from the well on Lynn's property in issue (Conflicting data reports the well depth any where from 20 to 60 feet). Test results showed contamination by TCE. The water samples were chocolate brown in color and had an objectionable odor.

1/17/83 Water samples taken from Tennessee Tile at 1313 South Loop West did not indicate presence of TCE; this well is 320 feet in depth.

4/12/83 Dalbey collected 3 soil samples from the Mansard Road ditch adjacent to the Lynn property. All three showed contamination by TCE and 2 by PCBs. Two soil borings from on-site showed TCE contamination.

12/12/83 Corrigan of TWC collected two soil samples, one from the parking lot behind the 1415 address and the other from close to the water well at the 1419 address.

1/16/84 Michael Warner, of Roy F. Weston Consultants and under the auspices of EPA, collected 16 soil samples and 3 water samples. Various of the soil samples tested positive for PCBs and TCE. One water sample collected from the tap at 1417 South Loop West contained TCE.

1/26/84 Corrigan of TWC collected two soil samples, one from the parking lot behind the 1415 address and the other in the empty lot between the 1403 and 1415 addresses. Both samples tested positive for PCBs.

2/29/84 Mike Dick of Solid Waste Enforcement Unit of TWC requests the Industrial Transformer site be ranked for corrective action through the Superfund Program.

4/16/84 The Hazard Ranking System for Industrial Transformer site was submitted to EPA, Region 6 to be included on the next update of the National Priority List.

5/24/84 Suit filed against Mr. Lynn, owner of properties located at 1415, 1417, and 1419 South Loop West and operator of Industrial Transformer Company; and Mr. Ken James, president of Sila-King, Inc.; and Sila-King, Inc., a Texas Corporation; in the District Court of Harris County, Texas.

000874

9/26/84 Announcement of grant award for Remedial Investigation/Feasibility Study (RI/FS) for the Industrial Transformer site, State of Texas and EPA.

10/5/84 Announcement of the inclusion of the Industrial Transformer site on the second update of the National Priorities List.

2/26/85 Susan Ferguson of TWC collected four soil samples from adjacent to and in the ditch on the north side of Mansard Road. All samples contained PCBs and one contained TCE.

3/6/85 Mr. Lynn collected six soil and one water samples. All soil samples reported PCBs and two contained TCE.

3/26/85 Mr. Lynn collected four soil and one water samples. Three of the soil samples collected on-site showed PCB contamination, one indicated TCE.

5/7/85 Mr. Lynn collected two water samples, one from 1403 South Loop West and the other from 1419 South Loop West. Both showed TCE contamination.

5/24/85 Mr. Lynn collected a water sample from the well at the rear of the building at 1419 South Loop West, which tested positive for TCE.

6/17/85 EPA pursues efforts to locate Mr. Ken Davis, president of Sila-King, Inc., which operated at 1415 South Loop West.

3/7/86 TWC published the Request for Proposals (RFP).

5/27/86 Selection of the consultant, Radian Corporation.

6/30/86 Execution of Remedial Investigation (RI)/Feasibility Study (FS) contract between the Texas Water Commission (TWC) and Radian Corporation.

10/13/86 Work plan or "Scope of Work" approved by TWC.

1/14/87 Field sampling activities start at ITS site.

4/30/87 Boring and Monitor Well Installation Program terminated at ITS site.

000875

EPA, and Mr. Lynn, (Letter; Texas Water Commission to Ms. Bonnie Devos, Chief, State Programs Section, U.S. EPA, Region VI; October 28, 1985). Soil and water samples have been collected and analyzed for TCE and PCBs. Consistent with the solubility and mobility characteristics of these compounds, PCBs were detected in soil samples only. TCE was detected in both soil and water samples.

Appendix A-3, Existing Surface Water and Groundwater Analysis Data, and Appendix A-4, Existing Soil Analysis Data, present a chronological summary of analytical data gathered from the site during the period 1981-1986. This summary includes soil, surface water, and groundwater samples. Also included are date and location of collection, collector affiliation and chain-of-custody information.

During the period of 1981-1986, a total of 101 soil samples were analyzed for PCBs and TCE. Fifty-four soil samples were analyzed for PCBs and 44 (77%) tested positive. The highest observed concentration was 99 parts per million (ppm). Figure 1-3 illustrates the location of the samples. Of the 47 soil samples analyzed for TCE, 34 or 72% tested positive. Distribution of samples is illustrated on Figure 1-4.

Of the 25 water samples, 4 were analyzed for PCBs and 21 for TCE. Of the 21 TCE analyses, 13 (62%) tested positive (all of which were groundwater samples) with a high value of 953 ppm. All three of the surface water samples, tested negative for TCE. Location of these samples is shown on Figure 1-5. Four samples collected from surface water and groundwater were analyzed for PCBs. The two surface water samples contained less than 1 ppm PCBs. The two groundwater samples contained no PCBs.

Summary conclusions based on consideration of existing data indicate:

- A review of Figures 1-3, 1-4, and 1-5 show that contamination is highly localized in Areas 3 and 4 and the eastern portion of Area 2.



**N.D. NONE DETECTED** \_\_\_\_\_

**2.37 SOIL SAMPLE VALUE**

- **SURFACE SOIL SAMPLE LOCATION**
- **APPROXIMATE LOCATION OF SURFACE SOIL SAMPLE**
- **APPROXIMATE LOCATION OF SHALLOW BORING SAMPLE**

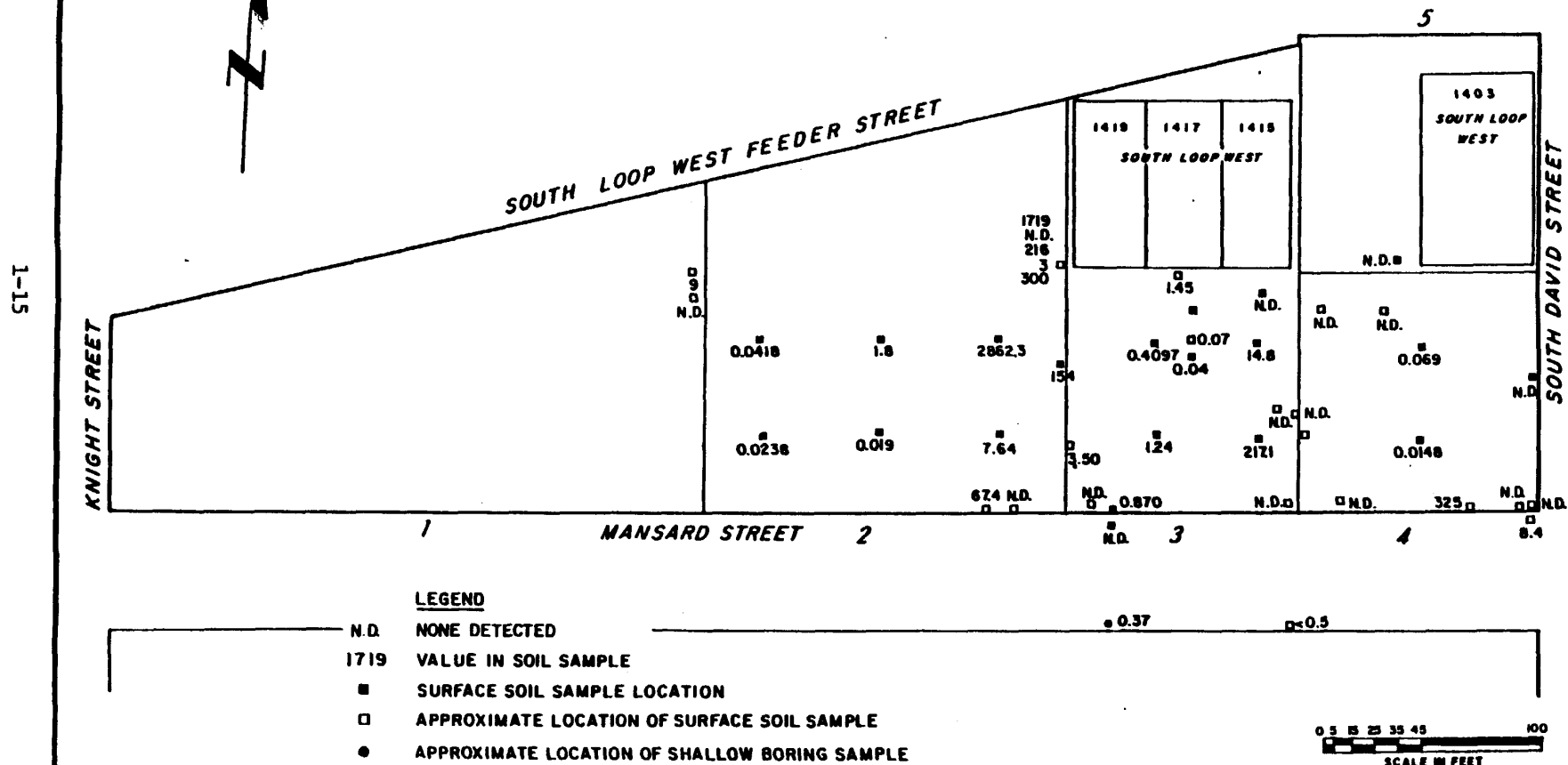
**NOTE: DUE TO THE UNCERTAINTY OF SOME SAMPLE LOCATIONS,  
NOT ALL DATA PRESENTED IN APPENDICES A-1 AND A-2 ARE PLOTTED ON THIS MAP**



0 5 15 25 35 45 100  
SCALE IN FEET  
**RADIAN**  
CORPORATION

000877

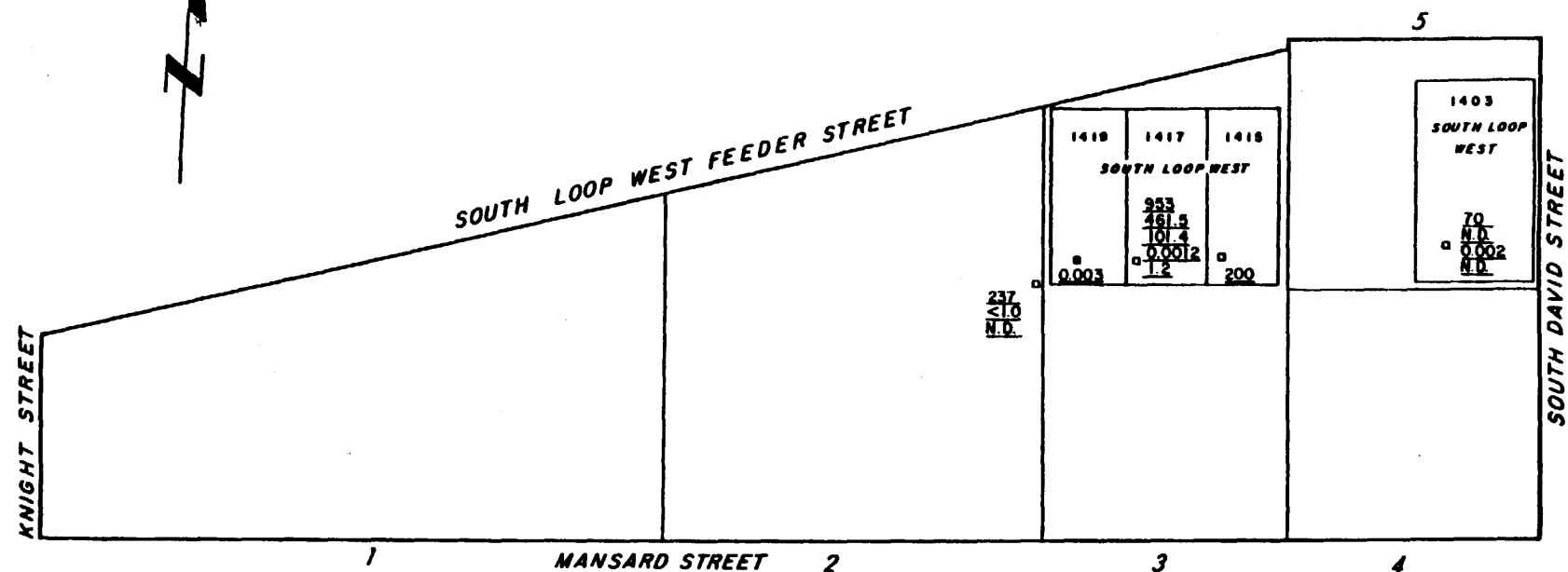
FIGURE I-4  
TCE VALUES (PPM) FOR  
SOIL SAMPLES  
COLLECTED BY TWC  
AND OTHERS



NOTE: DUE TO THE UNCERTAINTY OF SOME SAMPLE LOCATIONS,  
NOT ALL DATA PRESENTED IN APPENDICES A-1 AND A-2 IS PLOTTED ON THIS MAP.

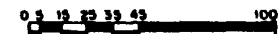
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FIGURE 1-5  
TCE VALUES (PPM) FOR GROUND  
WATER SAMPLES COLLECTED  
BY TWC AND OTHERS



**LEGEND**

- N.D. NONE DETECTED  
237 VALUE IN GROUNDWATER SAMPLE  
□ SAMPLE LOCATION



SCALE IN FEET  
**RADIAN**  
CORPORATION

NOTE: DUE TO THE UNCERTAINTY OF SOME SAMPLE LOCATIONS,  
NOT ALL DATA PRESENTED IN APPENDICES A-1 AND A-2 ARE PLOTTED ON THIS MAP.

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- Contamination follows the drainage patterns of the site, west and south to the drainage ditches along Knight and Mansard Roads.
- Exposure pathways for PCBs and TCE include direct contact, ingestion of surface water and groundwater, and air inhalation.
- Probable response to cleanup of PCBs and TCE contaminated soils to some level to be determined, include the following potential remedial technologies: no action; capping and revegetation; excavation and on-site landfill; excavation and off-site landfill; excavation, stabilization and on-site landfill; excavation, stabilization and off-site landfill; excavation and on-site incineration; excavation and off-site incineration; excavation and catalyzed wet air oxidation; excavation and activated sludge treatment; excavation and contained landfarm; excavation and chemical treatment; excavation and soil flushing/solvent washing; excavation and chemical dechlorination; excavation and glassification; excavation and biodegradation.
- Data gaps and insufficiencies include: unknown boundaries of surface contamination by PCBs and TCE, unknown depth of such contamination, inadequate delineation and magnitude of TCE contamination in surface water and in groundwater, unknown potential for airborne contamination, establishment of background soil and water quality standards, and surface area and volume of contaminated soils and water.

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#### 1.4

#### OBJECTIVES OF THE RI PROGRAM

The objectives of the RI program can be summarized as follows:

- Determination of nature and extent of PCB contamination in air, surface soil, sediment, subsurface soil and surface water;
- Determination of nature and extent of TCE contamination of soils, groundwater, and surface water;
- Determination of nature and extent of environmental contamination from any other hazardous substance;
- Determination of the data needed to develop remedial alternatives for dealing with any contamination characterized by the investigation; and
- Determination of public health risk and environmental risk due to exposure to PCBs and TCE at the ITS site.

STATEMENT OF WORK

In order to fulfill the objectives stated in Section 1.4, the following steps were developed as the Scope of Work. The overall Scope of Work has been divided into three steps:

Step 1: Presampling Activities include:

- Review of previous investigative activities and results, data gaps, and insufficiencies;
- Proposal of responses and remedial technologies to remediate PCB and TCE contaminated surface and shallow subsurface soil as listed in the previous Section 1.4, Objectives of the RI Program;
- Proposal of responses and remedial technologies to remediate TCE contaminated deep surface soil and water which will be addressed in the RI Phase II;
- An assessment of existing conditions at the ITS site; and
- Preparation of work plans including: Health and Safety Plan, QA/QC Plan, Sampling Plan and Project Management Plan.

Step 2: Field Sampling Activities include:

- Collecting surface soils and sediment samples and analyzing them for PCBs, TCE, priority organic pollutants (POP), and dioxins;
- Collecting shallow boring samples (0 to 4 foot total depth) and analyzing them for PCBs, TCE, POP, and dioxins;
- Collecting deep soil borehole (39 foot total depth) soil samples and analyzing for PCBs, TCE, POP and dioxins;
- Converting deep soil boreholes into groundwater monitor wells, completed in the uppermost water-bearing zone;
- Collecting monitor well (38 to 48.5 foot total depth) soil samples and analyzing them for PCBs, TCE, and POP;
- Collecting monitor well (99 foot total depth) soil samples underlying the uppermost water-bearing sand and analyzing them for PCBs, TCE, and POP;

18000

- Completing monitor well (99 foot depth) in the next lower water-bearing sand;
- Geotechnical testing of soil samples (sieve analyses, Atterberg limits and permeability);
- Completing a water well inventory of wells in a 1-mile radius of the site;
- Measuring static water levels in all wells and determining hydraulic gradient;
- Collecting surface water and sediment samples and analyzing them for PCBs, TCE, and POP;
- Collecting groundwater samples from the uppermost water-bearing sand and analyzing them for TCE and volatile priority organic pollutants (VPOP);
- Collecting groundwater samples from the intermediate water-bearing sand and analyzing them for TCE and VPOP;
- Collecting air monitoring samples and analyzing for particulates and PCBs.

Step 3: Site Characterization/Analyses which includes the definition of:

- Site geology and hydrology;
- Site features including demography, land use, soils types, natural resources, and climatology;
- Nature and extent of contamination and concentration levels;
- Volume of contaminated soil and water;
- Contaminant pathways and rates;
- Target receptors;
- Potential impact of that contamination on public health and the environment; and
- Gathering of data sufficient to evaluate potential remedial alternatives.

This remedial investigation reports data collected by field work conducted from January to February, 1987 (Step 2) and laboratory analyses (Step

3) completed. As is noted later (Section 1.6), the results of Step 3 activities indicated that additional field investigation is required to fully define the nature and extent of contamination. The description of this additional work and the results thereof will be documented in an addendum to this report.

#### 1.6 FUTURE WORK (PHASE II)

Based on results and conclusions as reported here, a second phase of field work is planned, concentrating on the following:

- Definition of the outer limits and concentration levels of the contaminant (TCE) plume in the uppermost water-bearing zone by use of water-sampling penetrometers and existing groundwater monitor wells,
- Sampling of the soil zone underlying the uppermost water-bearing zone and analyzing for TCE,
- Completion of monitor wells in the intermediate water-bearing zone,
- Sampling of the intermediate water-bearing zone and analyzing for TCE, and
- Definition of contaminant (TCE) plume (if any) and degree of contamination in the intermediate water-bearing zone.

Further, the feasibility study has been divided into two feasibility studies: one, discussing the remediation of the surface and shallow subsurface soils and another, detailing the remediation of deep subsurface soils and groundwater. This division is based upon the observation that most of the PCBs are limited to the first two feet of soil. TCE is usually at deeper levels in the soil and in the groundwater.

The remaining chapters of this RI report describe the site investigation program, the results of analyses of samples collected and characterization of the site based on the analytical results and the evaluation of existing data.

## SECTION 2

### REGIONAL SETTING

This section presents a brief description of the cultural and natural features observed at and in the vicinity of the site during the RI. Population and land use surrounding the ITS site are described in Section 2.1 Demography and Land Use. Distribution and characteristics of the soils are detailed in Section 2.2 Soils, while the depositional setting of the site is examined within a regional picture in Section 2.3 Regional Geology. The distribution and use of the available water resources are presented in Section 2.4 Groundwater Hydrology and Section 2.5 Surface Water Hydrology. Section 2.6 Natural Resources describes the resources including oil and gas production and agricultural activities located in the vicinity of the ITS site. Section 2.7 Climatology describes the climate of the area.

#### 2.1 DEMOGRAPHY AND LAND USE

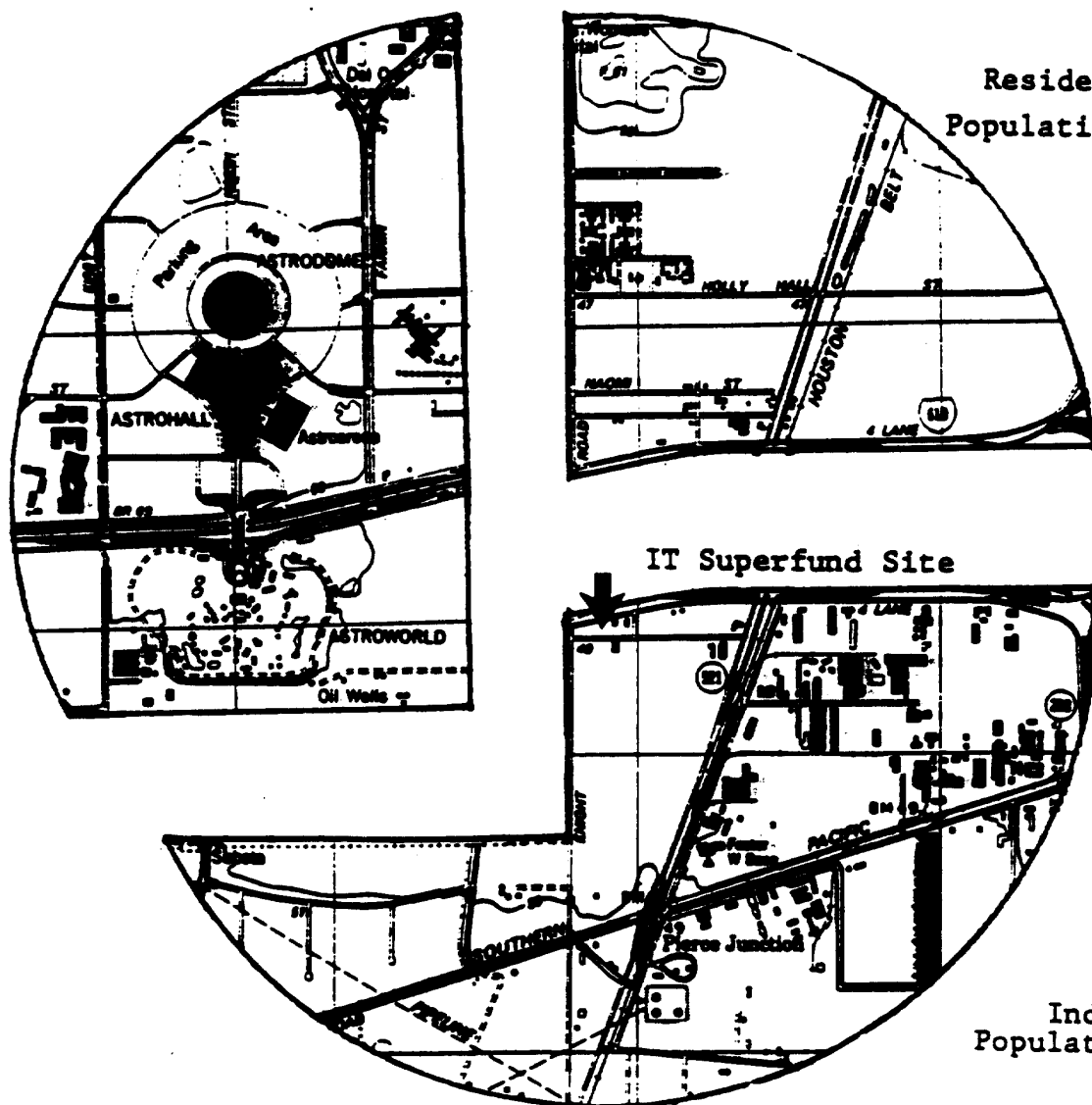
The ITS site is situated within the city limits of Houston, in Harris County, Texas. The ITS site is located on the feeder road of Interstate 610 South Loop (Figure 1-1). The interchange of State Highway 288 and I-610 are 1 mile to the east, with a large district of private single and multi-family dwellings located beyond the interchange. One and a half miles to the north are the buildings of the Medical Center. Rice University and Herman Park (a major City of Houston park) are approximately two miles north of the site. The Astrodome Complex and the Astroworld recreational facilities are about 2000 feet west of the site. To the west and northwest beyond the Astrodome and Astroworld complexes are areas composed largely of single and multi-family housing. The land use south of the ITS site is primarily commercial and light industrial.

Figure 2-1 shows the area enclosed within a one-mile radius of the site. The primary land uses are industrial/commercial, recreational, and residential. Some medical service facilities are also located in the area. Further details on the land use within this one mile circle follow.

Recreational  
Population: 100,000

Residential  
Population: 2,000

Industrial  
Population: < 250



000885

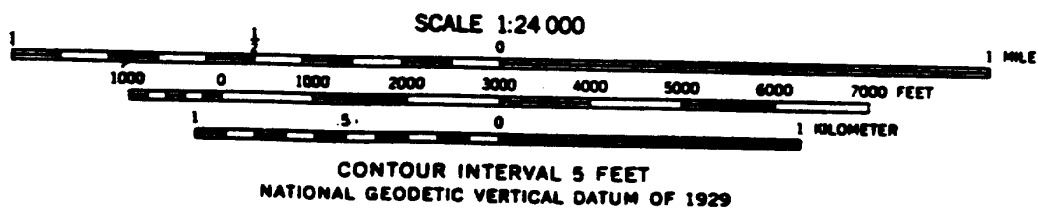


Figure 2-1

Land Use Patterns

The immediate vicinity of the site and the area south of the South Loop within the defined one-mile radius are an assembly of small business and light industrial concerns. These industries consist of commercial offices, warehousing, and manufacturing facilities. The major industry is International Tool and Supply Company with a worker population of about 100 persons (TDWR; Hazard Ranking System Submittal, Sol Lynn Site; April 16, 1984).

Also located south of the South Loop and immediately west of the site are the Astroworld and Waterworld recreational complexes. The two parks employ approximately 2,000 persons during the peak summer session. The combined average daily attendance at the two complexes is 17,500 persons (Personal Communication, Public Relations Dept., Astroworld/Waterworld, March 2, 1987). North of the South Loop is the Astrodome sporting and convention complex with a full time employment of 250 persons and an occasional attendance as high as 80,000 persons per day (Personal Communication, Public Relations Dept., Astrodome, March 2, 1987). A few hotels, mainly serving visitors to these recreational facilities, are also located in the area.

Residential usage in the vicinity of the site is primarily north of the South Loop. The residential facilities are mainly multi-family dwellings consisting of apartments, condominiums, and townhouses. There are also a few single family units located in the Knight-Main Street Subdivision. According to the 1980 Block Census Data for the City of Houston, 2061 persons reside within a one mile radius of the site. There are two hospitals within this area (TDWR; Hazard Ranking System Submittal, Sol Lynn Site; April 16, 1984). However, no schools are located within this area.

Considering the estimated area employment of 3,000 persons, the 17,500 average daily attendance at the Astroworld and Water world amusement parks, the occasional 80,000 attendance at the Astrodome complex, and the 2,061 residential population, the total daily area population may be as high as 100,000 persons.

## 2.2 SOILS

The ITS site is located in an area characterized by nearly level, clayey, prairie soils of the Lake Charles soil series. Within a one mile radius of the site, the soils are mostly of the Lake Charles series with the exception of the far northeast quadrant where soils are of the Beaumont series (Soil Conservation Service, 1976). These soils are suitable for crop or pasture; however, as described in the previous section, the area is mostly covered with urban development and/or is being held for development. No agricultural activity occurs in the vicinity of the site. Vegetation on land currently in use as improved pastureland includes bermuda grass and dallisgrass. Native pastures support andropogons and pasapalums. Live oak and huisache are locally common trees.

Lake Charles soil is somewhat poorly drained, a result of low permeability and little internal drainage. The available water capacity, which is the ability of the soil to hold water and make it available to plants, is high. When the soil is dry, deep wide cracks form on the surface where water can enter rapidly. When the soil is wet, the cracks seal and water infiltrates very slowly. Generally, the soils are only slightly susceptible to erosion. Specific physical and chemical characteristics of the Lake Charles soil are listed in Appendix B-1.

## 2.3 REGIONAL GEOLOGY

Harris County is located in the Western Gulf section of the Coastal Plain physiographic province of Texas. Sediments underlying Harris County were deposited during, from oldest to youngest, Pliocene, Pleistocene, and Holocene (Recent) epochs. All formations are composed of sediments deposited by fluvial, deltaic, coastal marsh, lagoon, and shallow marine processes. A typical stratigraphic column and aquifer column for the Houston-Galveston area is presented in Table 2-1.



Table 2-1  
Stratigraphic and Geohydrologic  
Column for Harris County

This report				Wood and Gebrysch (1965)	Sandeen and Wesselman (1969)	Wilson (1967)	Popkin (1971)	Lang, Winslow, and White (1990)	Pettit and Winslow (1957)	Wesselman (1971)	Anders and others (1968)	Wesselman (1972)													
System	Series	Stratigraphic unit	Aquifer	Houston district	Brasoria County	Austin and Waller Counties	Montgomery County	Houston district	Galveston County	Chambers and Jefferson Counties	Liberty County	Fort Bend County													
Q u a t e r n a r y	H o l o c e n e	Quaternary alluvium	C h i c o t  a q u i f e r  Upper unit	Confining layer and Alta Loma Sand of Rose (1943)	C h i c o t  a q u i f e r  Upper unit	Alluvium of the Brazos River  E v a n g e l i n e  a q u i f e r  (May contain unidentifiable parts of basal Chicot aquifer along the edges of Brazos River flood plain or along southern part of both counties)	C h i c o t  a q u i f e r	Alluvial deposits	Beach and dune sand	C h i c o t  a q u i f e r  Upper unit	C h i c o t  a q u i f e r	C h i c o t  a q u i f e r  Upper unit													
		Beaumont Clay											Beaumont Clay	Beaumont Clay	Beaumont Clay										
		Montgomery Formation	"Alta Loma Sand"		"Alta Loma Sand"			Lower unit	Lower unit	Lower unit	Lower unit	Lower unit	Lower unit	Lower unit	Lower unit	Lower unit									
		Bentley Formation															Zone 7	Zone 6	Liesle Formation						
		Willis Sand																							
T e r t i a r y	P l i o c e n e	Goliad Sand	E v a n g e l i n e  a q u i f e r	Heavily pumped layer	Evangelina aquifer		E v a n g e l i n e  a q u i f e r	Zone 5		Evangelina aquifer	Evangelina aquifer	Evangelina aquifer													
	M i o c e n e	Flaming Formation	Burkeville confining layer	Zone 2		Burkeville aquiclude	Burkeville aquiclude	J a s p e r  U p p e r p a r t o f J a s p e r  L o w e r p a r t o f J a s p e r	Zone 4	Zone 3	Zone 2	Zone 1	Jasper aquifer	Jasper aquifer	Jasper aquifer										
			J a s p e r  U p p e r u n i t																						
			J a s p e r  L o w e r u n i t																						

Source: Jorgensen, D.G., 1975.

000888

Formations outcropping in Harris County include the Goliad Sand (Pliocene), the Willis Sand, Bentley and Montgomery Formations and the Beaumont Clay (all of Pleistocene age) and recent alluvium (Quaternary). All formations gently dip towards the Gulf of Mexico. Also, all formations, except the Goliad Sand and alluvium of Quaternary age, outcrop in belts parallel to the shoreline of the Gulf of Mexico. The younger formations (such as the Beaumont) outcrop nearer the Gulf and the older ones (such as the Willis) outcrop further inland. In the subsurface, these formations are difficult to distinguish and are often classified as a single generic unit. Locally, the occurrence of salt domes and faults may cause reversals of the regional dip and thickening or thinning of overlying individual beds (TWDB, 1975).

The Willis Formation, spanning the Pliocene-Pleistocene boundary, is the oldest geologic formation cropping out in Harris County. It is composed mostly of sand and fine gravel and contains abundant iron oxide concretions. Depositional environments recognized within the Willis are fluvial-deltaic in nature (Soil Survey of Harris County, Texas; 1976).

The Bentley Formation (Pleistocene) is the next youngest geologic formation. The sediments composing the Bentley were deposited by fluvial-deltaic processes, similar to the Willis Formation. It outcrops in a small area of Harris County, mostly around the towns of Tomball and Huffsmith (Soil Survey of Harris County, Texas; 1976).

The Montgomery Formation (Pleistocene), overlying the Bentley, outcrops extensively in Harris County. Clay, silt and sand deposited in fluvial-deltaic environments comprise the Montgomery. Many sand pits have been opened in areas where this formation is exposed (Soil Survey of Harris County, Texas; 1976).

The Beaumont Formation, the youngest formation of Pleistocene age, is exposed over large areas of Harris County. It represents the last complete major fluvial-deltaic depositional phase, with some small areas of chenier and

lagoonal deposits. Accordingly, deposits are primarily ancient delta and delta plain. Sediments are dominantly clays and muds or deposits of clayey sands and silts. Clays and muds were deposited as interdistributary, abandoned channel fill, overbank fluvial or mud-filled coastal lake or tidal creek muds. Sands and silts represent the alluvium, levee and crevasse splays common to the meander belts of ancient distributary channels. Relict depositional patterns are visible where slightly elevated distributaries or meander ridges are separated from one another by intervening former surfaces of back swamps or flood basins. A pattern of meandering streams is often discernible on the surface of the ridges (Figure 2-2).

Physical properties of the clays and muds differ from the clayey sands and silts. Generally, the clays and muds exhibit low permeability, high water holding capacity and poor drainage. The clayey sands and silts are of more moderate permeability, moderate water holding capacity and moderate drainage. The ITS site is located in the predominant interdistributary clays and muds of the Beaumont Formation.

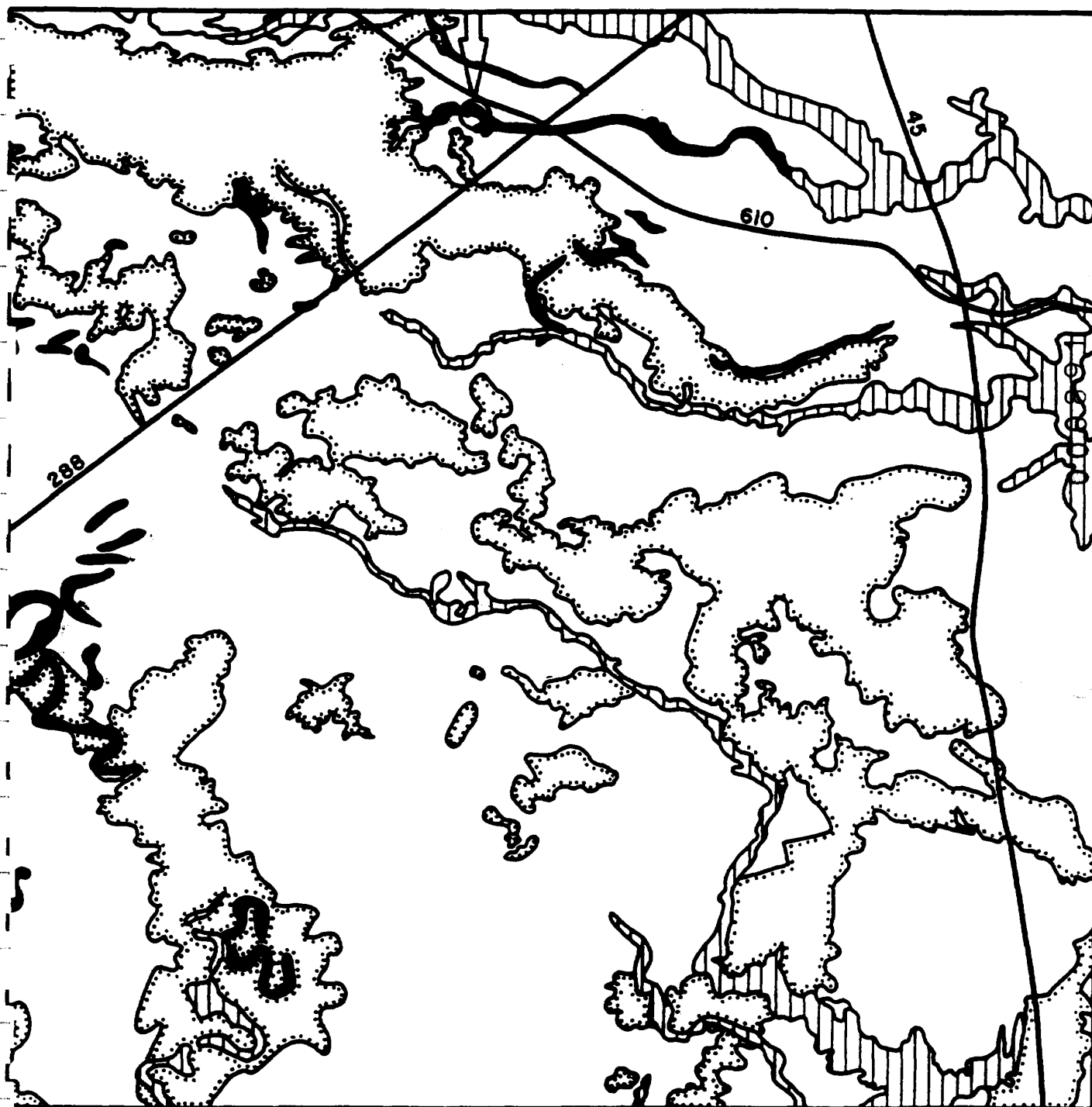
Alluvium of Holocene or recent age consists of clay, silt, sand and fine gravel deposited on flood plains and in marshy areas. It is derived from older Pleistocene deposits and occurs as deposits in channels, on levees, point bars and in backswamps.

#### 2.3.1 Faults and Lineations

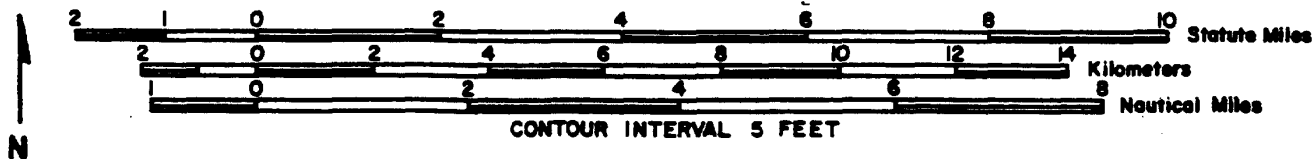
The Gulf Coast has undergone significant faulting. These faults can be divided into two categories, with some overlap between them (Kreitler, 1976):

- Growth faults which are commonly associated with river-dominated, high-mud deltaic depositional environments. Principal zones of growth faults occur as the delta-front sands prograde over the pro-delta front muds. These faults usually are long-trending and parallel the Gulf Coast.

# INDUSTRIAL TRANSFORMER SUPERFUND SITE



SCALE 1 : 125,000



**FIGURE 2-2**  
**MODERN AND PLEISTOCENE DEPOSITIONAL**  
**ENVIRONMENTS IN PART OF SOUTH**  
**HARRIS COUNTY**

Key to Figure 2-2

**PLEISTOCENE SYSTEMS**

**FLUVIAL-DELTAIC SYSTEM**



Abandoned channel and course mud-filled (Pleistocene and Modern)



Interdistributary mud, including bay and floodbasin facies



Distributary and fluvial sands and silts, including levee and crevasse splay deposits

**MODERN-HOLOCENE SYSTEMS**

**FLUVIAL-DELTAIC SYSTEM**



Small active headward-eroding streams, tree-covered, alluvium sand, silt, mud, alluvium absent locally

Source of Map and Key: Fisher, W.L. et al, 1972.

- A variety of fault types resulting from salt diapirs or domes penetrating the overlying sediment accumulations. Included are normal faults with single or multiple offsets, grabens, horsts, radial faults, tangential faults, and reverse or thrust faults. These faults are generally steeply dipping and occur in close proximity to the salt diapir.

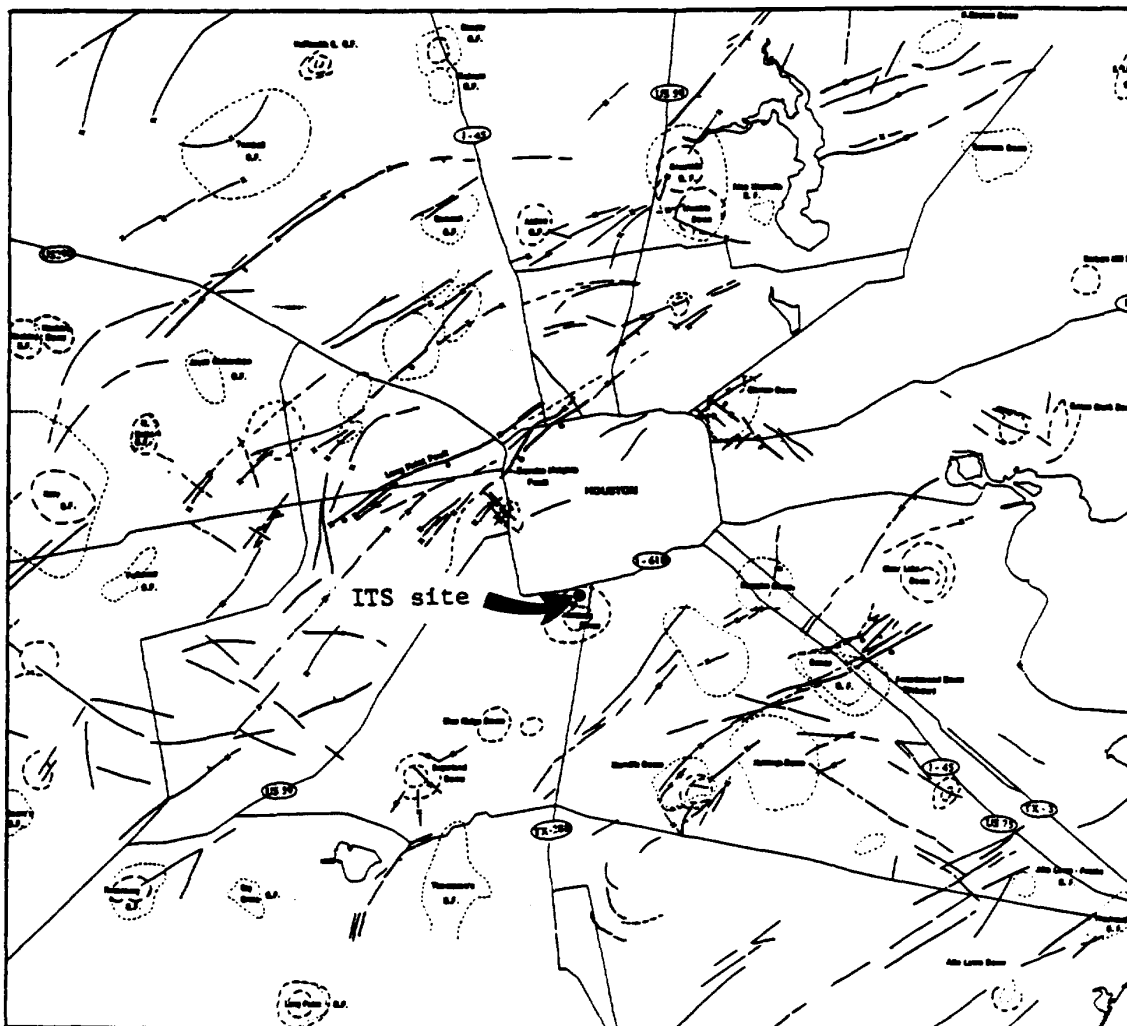
Lineations are defined by Kreitler (1976) as any "straight lengthy feature of the natural earth's surface and generally of geologic origin...represent(ing) a zone of variable width". Most lineations appear to be either fault-controlled (whether active or inactive), define joint systems, or are related to subsidence.

Figure 2-3 depicts faults, lineations and structural features (e.g. salt domes) in the Houston metropolitan area. Portions of the metropolitan area have numerous such features; however, only a salt dome and oilfield appear in the vicinity of the ITS site (Everitt and Reid, 1981).

#### 2.3.2 Subsidence

While many of the faults along the Gulf Coast are inactive, some faults have had renewed differential movement and are associated with land subsidence due to large scale groundwater pumping. On a smaller scale, pumping of groundwater associated with oil and gas from shallow reservoirs may have the same effect.

Ratzlaff (1982) explains subsidence as the process whereby a decrease in pore pressure occurs and causes an increase in pressure on the individual sediment grains. Pore pressure changes quite rapidly in coarse grained sediments, such as sand, in an artesian aquifer; but, pore pressure changes occur at a much slower rate in fine-grained sediments (e.g., clays, silts). The resulting pressure difference causes water to move from the clays into the sands. The clays compact, causing ground subsidence.



**Figure 2-3**  
**Structural Features in Houston and**  
**the Surrounding Area**

Structural features mapped from Landsat image. Heavy lines with ball and tick are previously mapped faults seen in the image. Heavy lines with a tick are inferred to be faults based on evidence seen in the image. Light lines are lineaments. Light-dotted, closed circles mark salt domes and oil fields compiled from existing maps. Heavier curved lines are features mapped from the image. Lines with "X's" are features that appear related to faults in the subsurface.

Source of Map and Caption:  
Everett, J.R. and W.M. Reid, 1981.

Verbeck and Clanton (1981) point out that there is no area of comparable size along the Texas Gulf Coast where the number of faults approach that of the Houston area. Factors contributing to this are: moderate to severe land subsidence, large water-level declines and petroleum production. As the aquifers are pumped, land subsides, typically ranging from 0.3 to 0.6 meters for every 30 meters of head decline depending on the proportion of clay to sand in the sediments (Gabrysch, 1969).

Ratzlaff (1982) states that ground subsidence in the Texas Gulf Coast is generally less than 0.5 foot; however, in the Houston-Galveston area, it is usually greater than 0.5 foot with a maximum observed subsidence between 8.5 to 9.0 feet, in the Pasadena-Houston Ship Channel area. In the vicinity of the ITS site, land subsidence between 1906 to 1973 was approximately 4.0 feet, or an average of 0.059 feet per year. Land-surface subsidence figures during the period 1906 to 1973 for the Houston area are displayed on Figure 2-4.

Gabrysch and Bonnet (1975) published a study on subsidence in the Houston-Galveston area. From 1906 to 1943, subsidence in the vicinity of the ITS site was approximately 0.65 feet, or an average of 0.0175 feet/year. During the period 1943 to 1973, subsidence totaled 3.5 feet, or 0.116 feet/year. In the period from 1964 to 1973, total subsidence recorded was about 1.5 feet, or an average of 0.166 feet/year. Changes in the rate of subsidence are related to changes in groundwater pumping (i.e. decline in water levels). The Chicot aquifer (near the ITS site) has declined about 170 feet from 1943 to 1973, an average of 5.66 feet/year. In the 1964 to 1973 period alone, the Chicot water levels dropped 55 feet in the vicinity of the ITS site, or an average of 6.1 feet/year. During the years 1943 to 1973, the Evangeline showed a water level drop of 225 feet for an average of 7.5 feet/year. Evangeline water levels near the ITS site dropped 70 feet or 7.77 feet/year. The greater decline in water levels from 1964 to 1973 coincides with a greater magnitude of subsidence.

Because of an anticipated decrease in groundwater pumpage by the City of Houston and an anticipated increase in surface water use, that future rates of subsidence are expected to decrease in the vicinity of the ITS site.



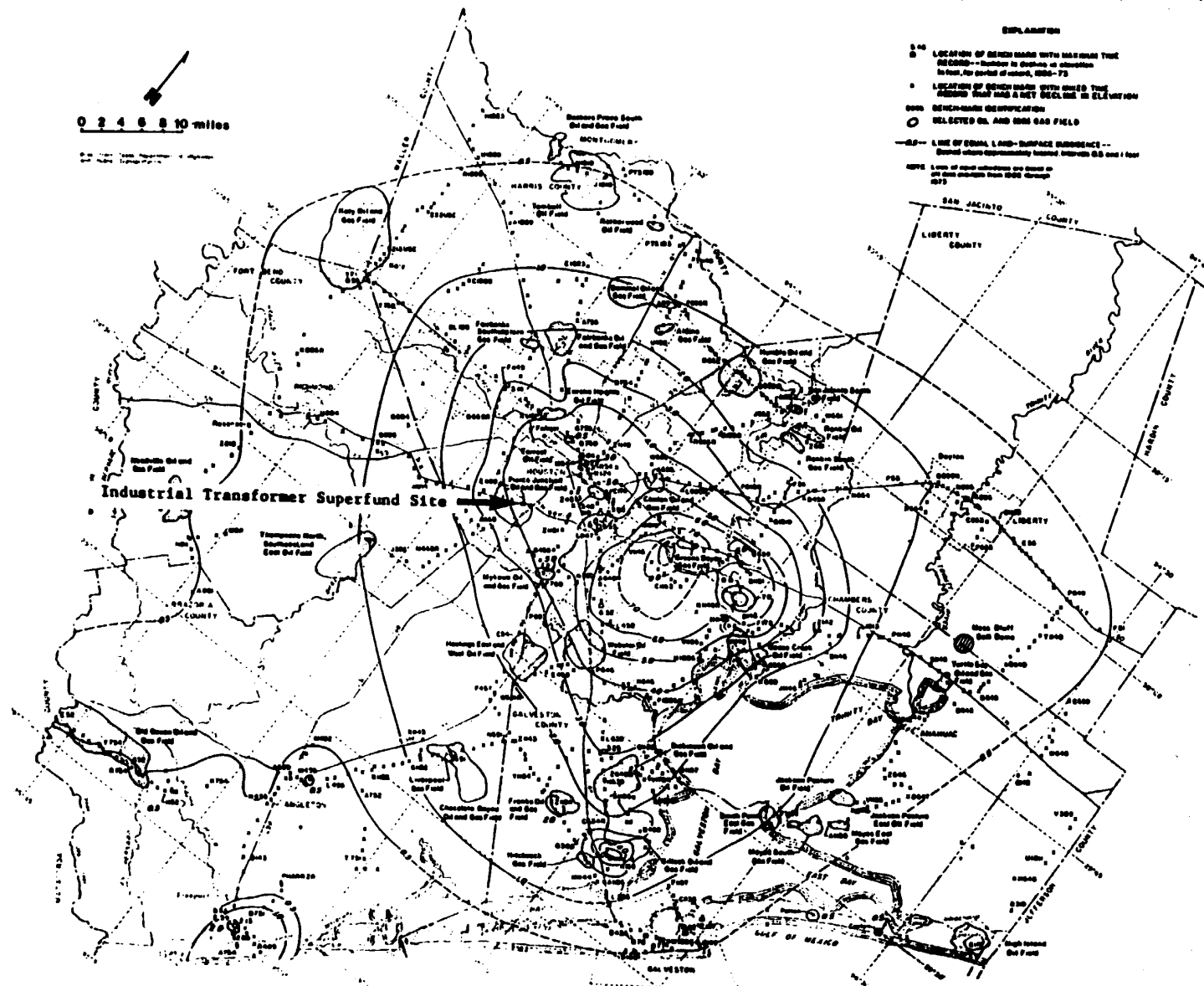


Figure 2-4

Land-Surface Subsidence 1906-73

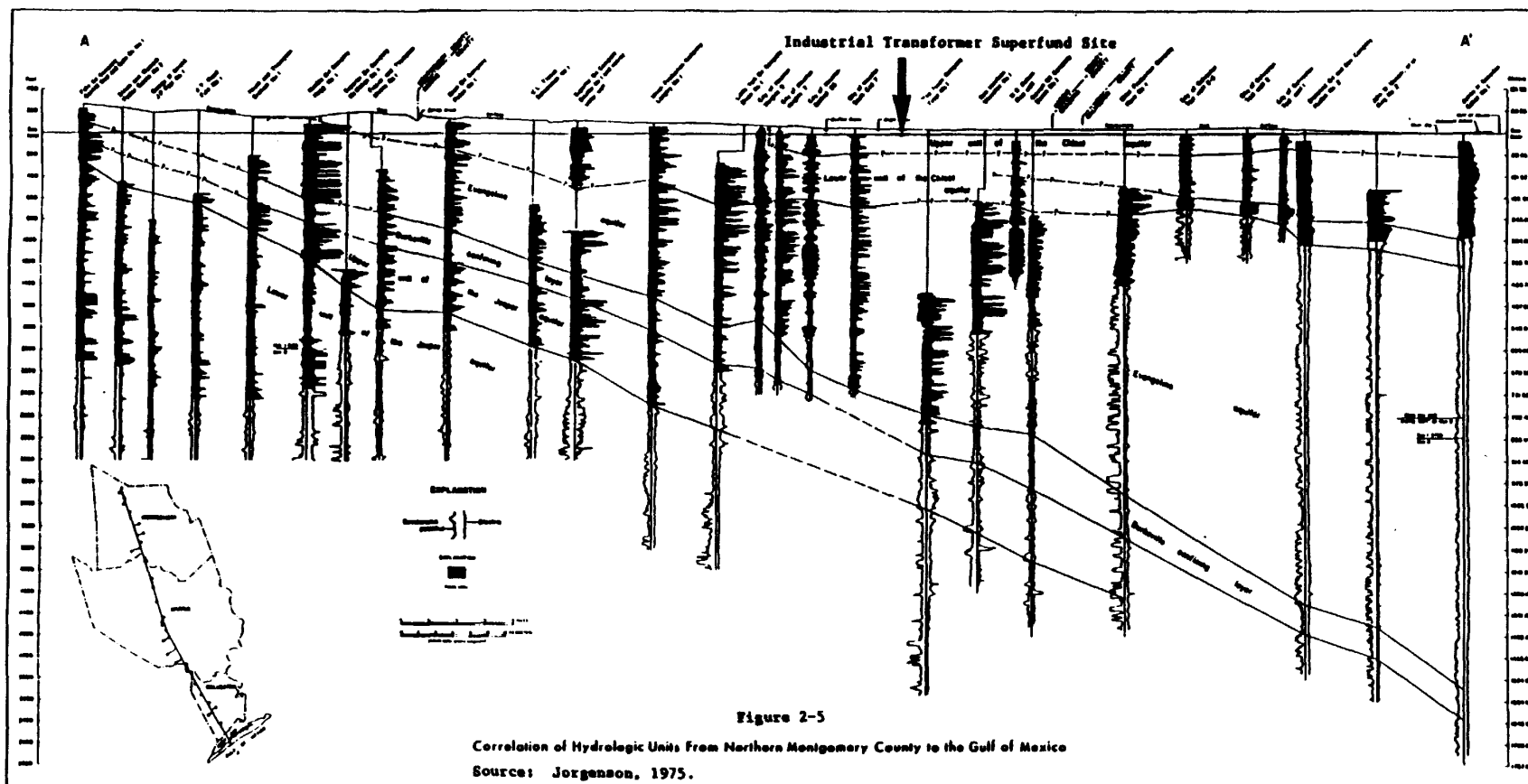
Source: Ratzliff, 1982.

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The two regional aquifers present in the Houston-Galveston area, the Chicot and underlying Evangeline, are composed of alternating beds of clay, silt, sand, and gravel. These beds were deposited in a series of fluvial-deltaic environments that were affected by rapid changes in sediment rate, regional subsidence of the Gulf of Mexico and changes in mean sea level since at least the end of the Tertiary period. All of these factors have caused individual beds to vary greatly. This variation occurs both vertically and laterally and makes differentiation of individual beds and correlation between them difficult. Many are hydrologically connected resulting in a "large, leaky artesian aquifer system" (Mueller and Price, 1979). While both aquifers contain sand and mud, the Chicot contains more permeable sand beds (Jorgensen, 1975) and the clays are of a more compressible type than those of the Evangeline (Gabrysch, 1984). Differences in hydraulic conductivity contribute to differences in the potentiometric levels in the two aquifers (Jorgensen, 1975).

The Chicot aquifer is composed of Willis, Bentley, Montgomery, and Beaumont Formations, all of Pleistocene age, plus overlying Holocene alluvium. While in the northern part of Harris County, the Chicot cannot be differentiated into upper and lower units, two sub-units of the Chicot can be defined in some places within the Houston-Galveston area, based primarily on water levels. Log and water level data in the vicinity of the ITS site also suggest two sub-units of the Chicot (Jorgensen, 1975). Figure 2-5 depicts the correlation of hydrologic units for the region surrounding the ITS site.

Transmissivity of the Chicot aquifer ranges from 1 to 20,000 feet<sup>2</sup>/day. The storage coefficient ranges from 0.004 to 0.20, with larger values reported in the northern part of Harris County and adjacent Montgomery County. The Chicot is the major aquifer in the vicinity of the site, and in Galveston County, the Chicot aquifer is the major source of groundwater.



The Evangeline aquifer generally includes the Goliad Sand (Pliocene age) and the upper part of the Fleming Formation (Miocene age), both formations consisting of sand and clay. Transmissivities range from less than 5,000 feet<sup>2</sup>/day (460 meters<sup>2</sup>/day) to 15,000 feet<sup>2</sup>/day (1400 meters<sup>2</sup>/day). The storage coefficient ranges from about 0.0005 to 0.0002 where it occurs under artesian conditions. Where the aquifer is under water-table conditions, such as in the outcrop area, the storage coefficient ranges from 0.002 to 0.20. Although updip in Harris County and producing fresh water which is a major drinking water source, the Evangeline aquifer is saline towards the south and, hence, is not a groundwater source in Galveston County.

The Burkeville aquitard or confining layer, which is in the upper part of the Fleming Formation, underlies the Evangeline aquifer. This formation is composed of clays with interbedded sands, and it occurs generally in the northern part of Harris County.

#### 2.4.1 Groundwater Withdrawals - City of Houston

The city water is supplied both by groundwater (mostly from the Evangeline) and surface water from Lake Houston. The southeastern parts of Harris County and Galveston County are supplied by groundwater from the Chicot aquifer, especially the Alta Loma, a basal sand in the Chicot.

Data compiled by Gabrysch (1984) indicate that, in 1975, groundwater withdrawals in the area were 183.1 million gallons per day (MGD), of which the City of Houston used 150.7 MGD. The city further supplemented the water supply with 73.7 MGD of water from Lake Houston. In 1979, groundwater pumping produced 233.5 MGD, of which the City of Houston used 203.0 MGD, supplementing it with 138.4 MGD of water from Lake Houston.

Gabrysch's data (1984) shows that the average rate of total groundwater pumping increased about 6% per year, and the use of surface water by the

City of Houston increased by about 20% a year. Total water usage increased an average of 8.7% per year. The increased use of surface water instead of groundwater may very possibly decrease the rate of subsidence in the Houston area. This rate of groundwater pumping caused the Chicot aquifer in the vicinity of the ITS site to decline about 15 feet probably due to groundwater withdrawals from the basal unit (Alta Loma Sand) of the Chicot, and mostly in southeast Harris County and Galveston County. The Evangeline water levels declined about 25 feet during the period 1975-1980 in the area of the ITS site.

Phase II of the RI will include the investigation and presentation of all significant groundwater development located near the ITS site.

#### 2.4.2 Regional Groundwater Quality

In general, the groundwater of the Houston area is of good quality, with the Chicot aquifer yielding waters higher in calcium bicarbonate ("hard" water) and the Evangeline producing sodium bicarbonate type ("soft") waters. Both aquifers contain only moderate amounts of minerals (dissolved solids) (Gabrysch, 1972).

Salt water encroachment is very probable in the Houston-Galveston area but due to inadequate monitoring, cannot be quantified. However, the chloride content in certain monitoring wells has not significantly increased in the past 5 years (Gabrysch, 1980).

Kreitler, et al. (1977) report that growth faults between Harris and Galveston Counties have hydrologically isolated the aquifer into two subsystems. Harris County waters are meteoric and extend to a depth of about 3,000 feet. Galveston County waters are mixed meteoric and saline, extending only about 1,000 feet in depth; the saline water may have its origins either in seawater intrusion or sediment compaction.

#### 2.4.3 City of Houston Water Quality

An analysis of both organic and inorganic constituents of Houston city water was run on July 13, 1987. The analysis consisted of surface water used by the City of Houston for drinking water purposes and was drawn from the municipal water treatment station located at Clinton and Federal Roads. Results are listed in Appendix B-2. Organic analyses included volatile organics, semi-volatile organics, herbicides and pesticides. All organic constituents were below detection limits.

#### 2.5 SURFACE WATER HYDROLOGY

Shallow ditches border the ITS site along two boundaries, Knight and Mansard Streets. Direction of the run-off flow along Knight Street is to the north and into a storm sewer at the intersection of Knight Street and South Loop 610 West. The storm sewer carries the drainage north along Knight Street to Braes Bayou (about 1.6 miles north of the ITS site) which empties into Buffalo Bayou, then the San Jacinto River Basin and finally to Galveston Bay. The location of Braes Bayou relative to the ITS site is shown in Figure 1-1.

Along Mansard Street, the water in the ditch flows in two directions. In the southwest direction, the ditch empties into another ditch along Knight Street. In the southeast direction (near the intersection of Mansard and South David Street), the flow trickles along a culvert to the east under Mansard and empties into the ditch on the south side of Mansard which appears to flow to the east. The water in the ditch flows to the storm sewer system which discharges into Braes Bayou, then to Buffalo Bayou, which empties into the San Jacinto River Basin and then to Galveston Bay.

San Jacinto River Basin drains approximately 4000 miles<sup>2</sup> in southeast Texas, including much of the City of Houston. According to data compiled by Hughes and Rawson (1966), approximately 20% of the precipitation in the San Jacinto River Basin will appear in the streams as run-off. Houston averaged

45.26 inches annually during the period 1931 to 1960, or about 9.0 inches of run-off in the streams. The gauging station at Huffman, Texas, upstream of the San Jacinto River where it empties into Galveston Bay, had a yearly mean discharge (1937 to 1953) ranging from 237 to 6,240 cubic feet per second (cfs); instantaneous flows ranged from 49 to 253,000 cfs.

Braes Bayou, which drains 95.0 miles<sup>2</sup> including the ITS site, has the highest average run-off, 14 inches, of any stream in the San Jacinto River Basin for two reasons. Braes Bayou drains the Beaumont Clay, where infiltration of rainfall is slower than sandier soils, and secondly, it drains a highly urbanized (largely paved) city area. The average discharge from 1936 to 1985 has been 128 cfs; maximum daily discharge was 29,000 cfs and minimum daily discharge was 0.1 cfs. Water discharge records on a daily basis for the years 1984 and 1985 are shown in Appendix B-3, as are water quality records for the years 1984 and 1985 (written communication, USGS, 1987).

According to the Flood Insurance Rate Management maps for Houston, the ITS site lies outside the 100-year flood plain.

## 2.6 NATURAL RESOURCES

The natural resources of the area include extensive oil and gas production, sulfur, brine, sand, clay, and gravel. Agricultural activities include cattle, rice, dairy products, cotton, truck crops, and grains. Heavy industry/manufacturing, such as refineries, petrochemical plants, and shipping dominate the western and northern shorelines of Galveston Bay and the Houston Ship Channel (Environmental Geologic Atlas of the Texas Coastal Zone - Houston-Galveston Area, 1972).

Bay and estuary waters of the Houston-Galveston area are utilized for commercial and sport fishing, recreation, transportation, and mineral production, such as fill material (dredge shell), as well as oil and gas production.

Within the one mile radius, as shown on Figure 2-1, there are oil wells in production, with the majority of a field to the southeast and within a 3 mile radius of the ITS site. The producing field is centered around a salt dome (Pierce Junction), where other related activities include brine production related to salt dome solution and the storage of liquid petroleum gas within those solution cavities. No faults or lineations are known to be associated with this particular salt dome.

An inventory of water wells within a one-mile radius shows 24 wells. Where information on total depth is available, it shows that the wells are completed at a variety of depths, from 77 feet to 844 feet. The inventory did not determine the use of this water (Table 2-2).

## 2.7 CLIMATOLOGY

The climate at the site and throughout the City of Houston is predominantly marine due to the proximity of Galveston Bay and the Gulf of Mexico. Prevailing winds are normally from the southeast and south. Weather is variable, and there are four seasons; although, winters are typically short and mild. The climate is generally characterized by abundant rainfall, high humidity, moderate temperatures, mild winters, and frequent fog (NOAA, 1985).

Skies are generally cloudy to partly cloudy with average winds at 7.8 miles per hour. The average temperature is 68 degrees Fahrenheit (°F). Nighttime (12:00 midnight) humidity averages 86 percent and daytime (12:00 noon) humidity averages 60 percent. The normal annual rainfall is 44.76 inches. The 100 year, 24-hour rainfall for the Houston metroplex is 13 inches (NOAA, 1985; Harris County Flood Control District, 1983).



TABLE 2-2  
WATER WELL INVENTORY  
 (Within 1 Mile Radius from Industrial Transformer Site)

<u>Owners Name</u>	<u>Source</u>	<u>Well No.</u>	<u>Total Depth</u>	<u>Year Drilled</u>
Exxon Corporation	Houston Galveston Subsidence Dist.	3429	77	1979
Dresser Magcobar-Alameda Plant	"	1626	542	1956
International Tool & Supply Co.	"	3174	542	1956
International Tool & Supply Co.	"	2787	468	1962
International Tool & Supply Co.	"	2786	N/A	1981
International Tool & Supply Co.	"	3928	N/A	1981
Southwestern Bell Telephone Co.	"	3223	N/A	1968
Texaco, Inc.	"	2807	289	1967
Exxon Company, U.S.A.	"	2992	N/A	N/A
Harris County c/o County Judge	"	3298	150	1966
Black-Broiler Co.	U.S.G.S.	LJ-65-21-601	329	1952
Institute Place	"	LJ-65-21-605	310	1928
Magcobar Mud Co.	"	LJ-65-21-610	320	1946
Magcobar Mud Co.	"	LJ-65-21-611	542	1956
Metal Arts Co.	"	LJ-65-21-614	468	1962
Metal Arts Co.	"	LJ-65-21-615	540	1966
Star-Tex Oil Co.	"	LJ-65-21-616	292	1966
Signal Oil Company	"	LJ-65-21-617	290	1966
Houston Gulf Gas Co.	"	LJ-65-21-618	211	1929
Harris County Flood Control Dist.	"	LJ-65-21-620	432	1960
International Tools	"	LJ-65-21-624	337	1978
Charles W. Patronella	"	65-2 -6K	321	1975
Wanda Petroleum Corp.	"	65-21-9L	844	1974
Metal Arts	"	65-21-6L	337	1978

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SECTION 3  
SURFACE SOIL AND SHALLOW BORING INVESTIGATION

This section describes the surface soil and shallow subsurface soil (0 to 4 feet) investigation program. As evident from past sampling activities (see Section 2), principal contaminants of concern at the site are PCBs and TCE. The first subsection (3.1) deals with surface soil and the second subsection (3.2) deals with shallow subsurface soil samples.

Each subsection presents: purpose of the sampling program, sampling locations, procedures for sampling, analytical procedures, results and a preliminary discussion of the results. TCE and PCBs are discussed separately under each heading.

3.1 SURFACE SOIL SAMPLING

Surface soil sample locations were selected to verify and supplement the previous data, which had indicated PCB and TCE contamination of soils, collected at the site by the TWC and others. In addition, the following factors were taken into consideration: history of spills, drainage, downgradient location, and upgradient background. The objectives of the data collection program were to complement existing data and to provide a finer delineation of the areas of contamination.

A review of existing data (Section 1-2) as well as of past practices at the ITS site shows that Areas 3, 4 and part of Area 2 (see Figure 1-3) show significant evidence of being contaminated. These contaminated areas are the empty lots behind the 1403, 1415, 1417, and 1419 South Loop West addresses. Further, there was little or no data in Areas 1 and 2 (Figure 1-3). Hence, these particular areas became the prime candidates for additional surface soil sampling to provide an initial assessment of the level of contamination in these areas. The soil sampling program was planned to be completed in two

rounds. The second round was to provide further definition of the limits of the contaminated areas which may have been identified in the first round.

### 3.1.1 Sample Type, Location and Number

During the first round of surface soil sampling, a total of 26 samples were collected for PCB and TCE analysis. Of the 26 samples, 25 (Nos. 2\* to 26) were collected on-site and one sample collected off-site. One sample (No.28) was collected from east of South David Street where dirt from the site might have been hauled and dumped according to on-site business employees. In addition, as part of the QA/QC program, two samples were used to satisfy the field blank requirements. Also, as part of the QA/QC program, two co-located replicates (Nos. 22 and 23) were collected from the same location, but labeled uniquely and sent to the lab for PCB analysis. One additional field blank was analyzed for TCE. These samples, as well as others collected throughout the remedial investigation and generated by individual laboratories, are discussed in a separate QA/QC report.

A second round of surface soil sampling, conducted at a later date by Radian, further defined the boundaries of contaminated areas. This second round of 17 samples (Nos. 31 to 47) concentrated on Areas 3 and 4. The data collected previously by regulatory agencies and by Radian in the first round of sampling indicated the presence of PCBs in those areas.

In the second round, sixteen of these seventeen samples were collected at the ITS site (Nos. 32 to 47). The seventeenth sample (No. 31) was collected from a vacant lot across South David Street to act as a background "soil quality" sample. One sample was used to satisfy the field blank requirements. Two more co-located replicates (Nos. 36 and 37) were collected from the same location, labeled uniquely, and sent to the lab for analysis as part of the QA/QC requirement.

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\*Surface soil sample Nos.1 and 17 exceeded laboratory holding times for analyses, thus, data from these samples are not presented in the Remedial Investigation report. These sample data are discussed in the Quality Assurance/Quality Control report for the ITS site.

Property owner Mr. Lynn retained the consultant firm, Environmental Resources and Technology (ERT), to represent his interests. Surface soil samples Nos. 22, 24, and 26 were collected during the first round of surface soil sampling and split between ERT and Radian. Each split sample was analyzed separately. Only Radian-generated analyses are reported in this section of the RI.

### 3.1.2 Sampling Method and Procedure

Procedures used for surface soil sampling were as follows:

- Vegetation and trash were removed using a clean hand-held rake;
- Chrome-plated steel trowels were used to collect the upper two to three inches of soils;
- Visible and olfactory contamination were noted and the sample was screened for volatiles by holding the "wand" of the HNu analyzer within two inches of the sample while the sample was in the trowel;
- Trowels were cleaned with acetone and de-ionized water between samples and the water was drummed along with other water used for cleaning purposes, as specified in the ITS Project Sampling Plan, 1986;
- The samples were transferred to clean glass sample bottles with teflon-lined caps, labeled, stored in a cooler and transported to the lab for analysis. Chain-of-custody procedures were followed, as specified in ITS Project Sampling Plan, 1986; and
- Surface soil samples were stored for later dioxin analysis in labeled ZIPLOC® storage bags. Bags were stored on-site within the secured decontamination area.

The HNu was used in the surface soil and other soil sampling programs in order to measure volatile organic contamination and thus guide TCE sample selection. A positive HNu reading indicates the presence of a variety of volatile organics, including TCE; a negative HNu reading is a relatively good predictor of the absence of TCE. Technical information concerning the HNu is presented in Appendix C-1. The efficiency of this sample screening

process is described in Appendix C-2 and graphically depicted in Appendix C-3. Data in Appendix C-4 indicates that the HNu can identify samples containing volatile organics, of which TCE is one, as contaminants. The absence of an HNu reading also correlates, with limited efficiency, to the absence of volatile organics, of which TCE is one such possibility.

### 3.1.3 Analytical Methods and Procedures

None of the 43 surface soil samples screened by an HNu analyzer showed positive readings. Therefore, four surface soil samples (Nos. 9, 17, 21, and 22) were selected for TCE analysis. The choice of samples was based purely on the proximity of sample locations to previously identified areas of contamination. Because TCE is a volatile organic and is thus not expected to be found in high concentrations in surficial soil samples, only one surface soil sample (No. 22) was also analyzed for POP, which include TCE. One field blank was analyzed as well for POP. PCBs tend to adhere to soil particles, and hence, all 43 sample were analyzed for PCBs. Three samples containing the highest concentrations of PCBs found in the surface soil samples were selected for dioxin analysis (Nos. 13, 22, and 39). One additional sample was selected from the shallow borehole samples, discussed further in Section 3.2.1.

Appendix C-4 presents the analytical methods and preservation requirements for surface soil samples.

### 3.1.4 Results and Data Analysis

This subsection presents the data collected in the surface soil sampling program. Also, included are a comparison of the data collected in this investigation and data collected in the previous programs (by other regulatory agencies).

#### 3.1.4.1 Results and Data Analysis of Soil Samples Collected During RI

##### Polychlorinated Biphenyls (PCBs)

PCB values for surface soil samples collected during this RI are summarized in Table 3-1. Distribution of all surface soil samples and corresponding values are illustrated in Figure 3-1, where the entire site area is divided into five areas for purposes of discussion. The degree of contamination varies widely across the property. This is expected, due to the distance from the actual industrial activity and drainage patterns of the site. In Area 1 which is furthest away from industrial activity, values range from no PCBs detected to values less than 1 ppm. In Area 2, there is wide variation in PCB concentrations. PCB values range from less than 1 ppm to 130 ppm (No. 13). Values are in general higher at the eastern boundary, which is closer to the industrial activity and may have received PCB via surface run-off from Area 3. In addition, industrial activities may have actually occurred on the eastern portion of Area 2. In Area 3, directly behind the metal warehouse/office space (street addresses 1415, 1417, and 1419 South Loop West), there seems to be a high concentration of locations with high PCB values. These values range from 3 ppm (No. 44) to 118 ppm (No. 22), occurring in a random, highly localized pattern. The random pattern is probably a result of an unorganized pattern of industrial activity impacted by site drainage features. In Area 4, there is again a wide range of PCB values reported in a scattered, highly localized distribution. Values range from a low of 0.6 ppm (No. 26) to 220 ppm (No. 39).

Surface soil sample No. 31 was collected off-site, from a vacant lot on the east side of South David Street, to act as a background soil quality sample. This sample contains 1.2 ppm PCBs. PCB contamination may have been from another, unrelated source at that location, or contaminated soil might have been hauled in and dumped at or near that location.

TABLE 3-1  
POLYCHLORINATED BIPHENYL (PCB) DATA

Surface Soil Samples

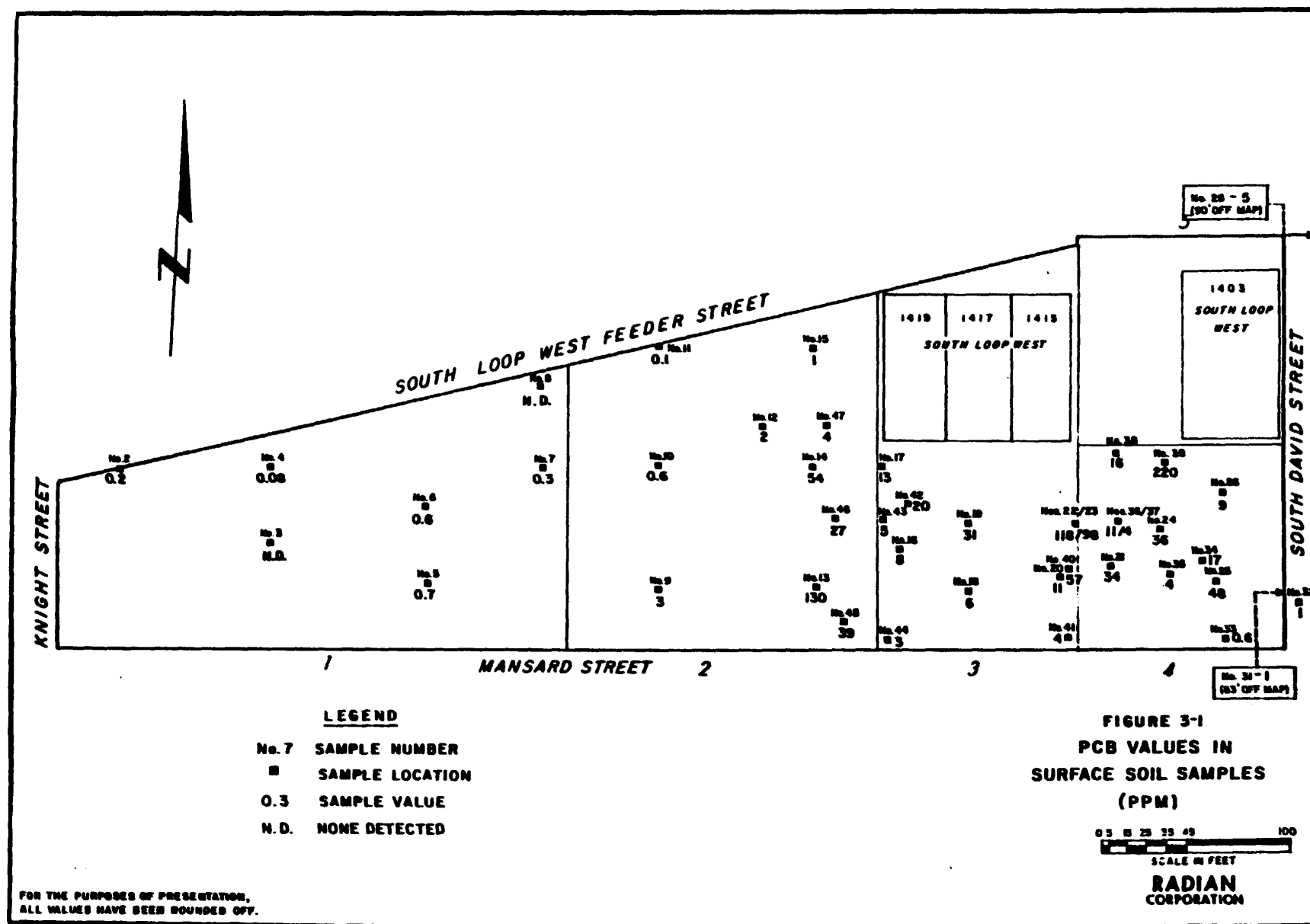
<u>Sample Identification</u>	<u>Value (ppm)</u>
SS-2*	0.19
SS-3	N.D.
SS-4	0.08
SS-5	0.74
SS-6	0.56
SS-7	0.27
SS-8	N.D.
SS-9	3.3
SS-10	0.6
SS-11	0.14
SS-12	2
SS-13	130
SS-14	54
SS-15	1
SS-16	7.93
SS-17	13
SS-18	6.1
SS-19	31.1
SS-20	11.37
SS-21	33.7
SS-22	118
SS-23	98
SS-24	36
SS-25	48
SS-26	8.9
SS-28**	4.6
SS-31	N.D.
SS-32	1.1
SS-33	0.65
SS-34	17
SS-35	4.4
SS-36	11
SS-37	4.4
SS-38	16
SS-39	220
SS-40	57
SS-41	4
SS-42	20
SS-43	5.4
SS-44	3.2
SS-45	39
SS-46	27
SS-47	3.5

\* The designation "SS" refers to surface soil samples; each is plotted on Figure 3-1 as "No. 2" and so forth.

\*\* Two QA/QC samples numbered 29 and 30 are not listed here.

N.D. - Not detected

Note: Surface soil samples Nos. 1 and 27 exceeded laboratory holding times for analysis and therefore data results are not listed in this table. The QA/QC report discusses these samples in more detail.



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Three samples containing the highest amounts of PCBs of all the samples, plus one other sample with a much lower amount of PCBs, were selected for dioxin analyses. The results of dioxin analyses are given in Table 3-2. None of the samples showed any dioxins.

#### Trichloroethene (TCE)

TCE values for surface soil samples are summarized in Table 3-3. Distribution of the four soil samples and corresponding values are illustrated in Figure 3-2.

The range of values varies from 0.02 ppm (No. 9) to 2 ppm (No. 17). Samples in Areas 3 and 4 are slightly higher in TCE concentration than the Area 2 sample, probably because of the proximity of these areas to the spill locations (punctured barrels). Approximate locations of barrels are documented in Section 1.2 Site History. As expected, because of the volatility of TCE, the concentration of TCE is low in surface soil samples.

POP data (Table 3-4) for soil sample No. 22 indicate the presence of 0.0018 ppm TCE. Other organic compounds detected are methylene chloride, acetone, and chrysene. Methylene chloride and acetone may be associated with field cleaning and laboratory procedures (Radian, 1986).

#### 3.1.4.2 Comparison with Previously Collected Data

#### Polychlorinated Biphenyls (PCBs)

Figure 1-3 illustrates the distribution of surface samples (and two shallow borings\*) on and adjacent to the ITS site collected previous to this study by various regulatory agencies. A total of 50 sample locations are plotted. An additional four sample locations were not plotted because of lack of precision in location description. Area 1 shows no detected PCB contamination. On the west side of Area 2, values range from none detected to a high

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\* The shallow borings are analyzed in this section with surface soil samples because of a lack of information regarding total depth of borehole or how sample was composited.

TABLE 3-2

## DIOXIN DATA

<u>Sample Identification</u>	<u>Dioxin Value</u>	<u>PCB Value (ppm)</u>
SS-13*	N.D.	130
SS-22	N.D.	118
SS-39	N.D.	220
B8; ST-1**	N.D.	0.91

\* The designation "SS" refers to surface soil samples.

\*\* The designation "B" refers to a shallow borehole, which is divided into an upper section, 0 to 2 foot depth, sampled by Shelby tube (ST) and labeled ST-1. A second sample is from the 2 to 4 foot depth and collected using a Shelby tube (ST) and labeled ST-2. This sample is discussed separately under Sub-Section 3.2 Shallow Borings.

N.D. - Not Detected

TABLE 3-3

TRICHLOROETHENE (TCE) DATA

Surface Soil Samples

<u>Sample Identification</u>	<u>Value (ppm)</u>
SS-9*	0.018
SS-17	1.6
SS-21	1.2
SS-22	0.55

\* This designation "SS" refers to surface soil samples. Each location is plotted on Figure 3-3 as "Number 9" and so forth.

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TABLE 3-4

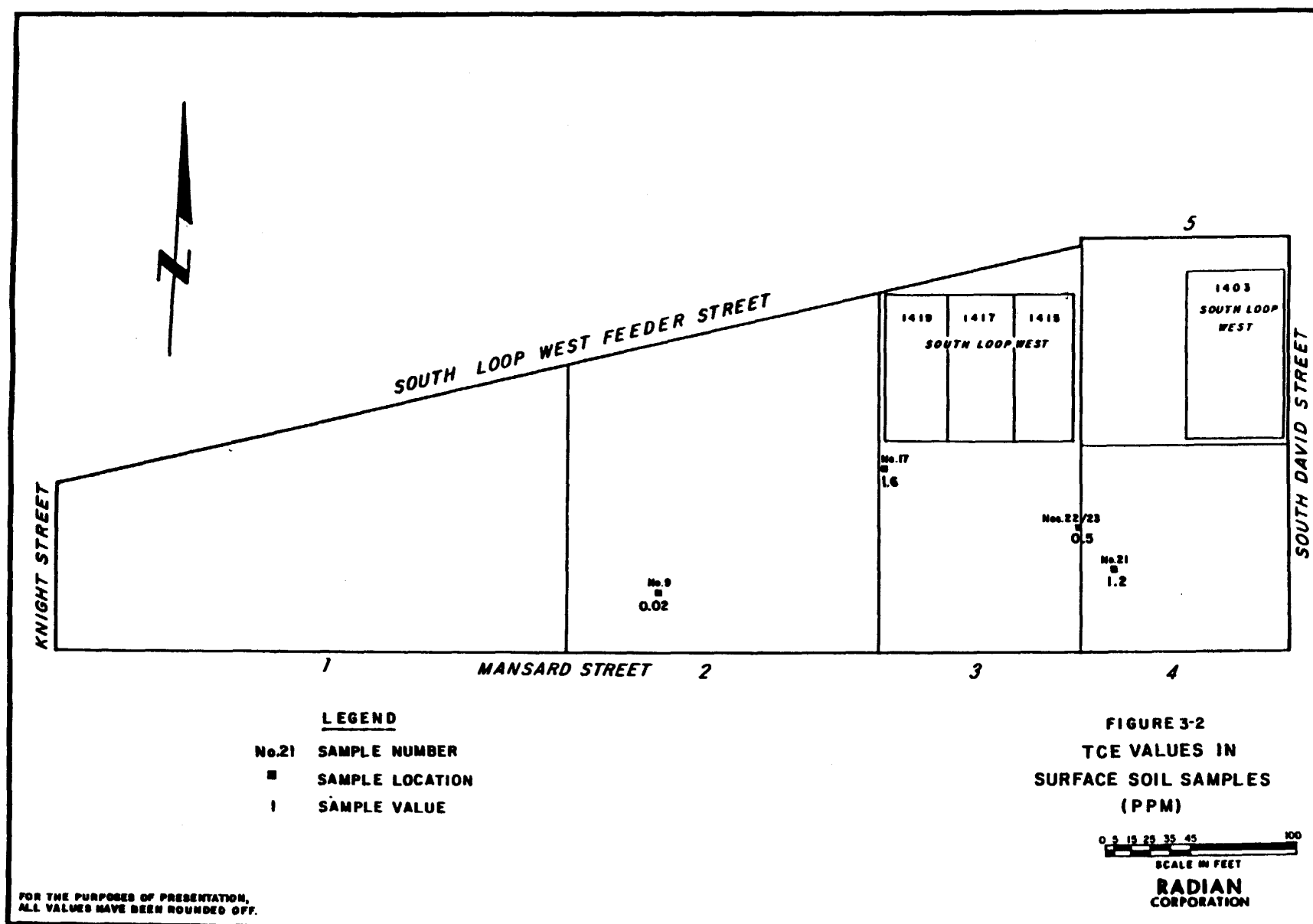
## PRIORITY ORGANIC POLLUTANTS (POP) DATA

Surface Soil Samples

<u>Sample Identification</u>	<u>Depth</u>	<u>Compound</u>	<u>Value (ppm)</u>
SS-22*	-	Methylene chloride	0.0049
		Acetone	0.0074
		Trichloroethene	0.0018
		Chrysene	0.42

\* This designation "SS" refers to surface soil samples.

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value of 24.7 ppm. In Area 3, there is a wide range of values scattered in no apparent pattern. Values range from a low of 0.13 ppm, located near the southwest corner of the building at 1419 South Loop West, to 99 ppm, located on the eastern edge of Area 3. Of special interest are the three samples within Area 3 which are about six feet apart. The values range from 5.66 ppm to 12 ppm to 32 ppm. This is illustrative of the random and localized nature of contamination. In Area 4, values range from 0.0149 ppm to 57 ppm with one value of none detected in the southeastern corner of the plot. No PCBs were detected in the one sample collected in Area 5. Values above 25 ppm are limited to those samples collected in areas 3 and 4. Overall, the data collected previously and that collected by this RI confirm each other, with the exception of Area 5, where PCB values collected during this RI exceeded those found in previous investigations by regulatory agencies.

#### Trichloroethene (TCE)

TCE values for surface soil samples from previous investigations are summarized in Appendix A-3. Distribution of the samples is illustrated in Figure 1-4. In Area 1, one sample contained no detectable amounts of TCE and the other contained 9 ppm. In Area 2, TCE values were quite low (less than 1 ppm) and became higher as sampling locations moved closer to the buildings. A high value of 2862.3 ppm was observed near the building. In Area 3, soil sample values ranged from less than 1 ppm to 217.1 ppm. In Area 5, values ranged from less than 1 ppm to a high of 325 ppm, the latter in a sample location near the ditch on the north side of Mansard Street. Amounts less than 1 ppm were found in soil samples taken from a ditch on the south side of Mansard Street.

Sample values vary not only due to the original amount of TCE spilled and proximity of the sample point to the spill point, but the values also vary widely because of the ease of volatilization that is characteristic of TCE. Because of volatilization, the RI analyses revealed little TCE in soil samples. All industrial activity which may have resulted in the spilling of TCE had ceased in 1981.

### 3.2 SHALLOW SOIL BORINGS

The shallow soil borings consisted of collecting soil samples from depths of 0 to 4 feet. Locations of the shallow borings were chosen for two reasons: to test for the presence of PCBs and TCE in Areas 1 and 2 and to further define the extent of contamination in Areas 3 and 4, where previous sampling by regulatory agencies (see Section 1-2) had established the presence of these contaminants. Other factors taken into consideration include: history of spills, drainage, downgradient location and upgradient background. The data to be collected in the RI was to complement existing data and result in a more precise definition of contamination in shallow subsurface soil.

Based upon these criteria, a total of eighteen shallow boring locations were identified. These borings were located in the field. The locations were modified to the extent necessary to achieve easy access.

#### 3.2.1 Sample Type, Location, and Number

Eighteen shallow borings were each drilled to a depth of 4 feet. Each boring resulted in two samples, one from an upper 2 foot section and one from a lower 2 foot section. A 37th sample, which was a composite sample over the entire 4 foot depth, was collected from a location on Mansard Street. In all, 19 borings were drilled and a total of 36\* samples were collected during the shallow soil boring program. Each sample was analyzed separately for PCBs. Two field blanks were also analyzed for PCBs. A total of 18 samples were analyzed for TCE; selection of samples to be analyzed in the laboratory was based on HNu reading plus previously mentioned factors. One field blank was analyzed for TCE. One sample was analyzed for dioxins. This sample was chosen for dioxin analysis based on anticipated relatively high PCB values. The PCB values were anticipated to be high based on proximity to the industrial work

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\*Shallow borehole sample B-12/St-2 exceeded laboratory holding times for analyses. Therefore, data from this sample is not presented in the Remedial Investigation report. This sample data is discussed in the Quality Assurance/Quality Control report for the ITS site.

area and other samples with high values. POP analysis was performed on composite samples from four shallow boreholes. These samples were chosen based on HNu reading plus previously mentioned factors.

### 3.2.2 Sampling Method and Procedures

A Shelby tube was used to collect the shallow soil boring samples. Detailed descriptions taken by the geologist on-site are in Appendix B-2. The sampling for PCBs and TCE proceeded as follows:

- Surface vegetation and trash were removed with a clean hand-held rake.
- The drilling rig was set over the proposed location of the shallow borehole and the Shelby tube was advanced to a 2 foot depth and brought up to the surface, where the core was extruded.
- The Shelby tubes were steam-cleaned and kept free of contamination in between sampling intervals.
- The sample was screened for volatile organics using a HNu analyzer and the reading was recorded.
- A geologic description of the core was recorded.
- The sample was trimmed and placed in labeled glass containers with teflon-lined caps. Sample size conformed to the size specified for the type of analysis performed.
- The second tube sampler was advanced to the final depth of 4 feet. The sample was extruded, screened, described, trimmed, stored, labeled, and shipped according to the procedures outlined in the Project Sampling Plan (Radian, 1986).
- Leftover core material from this stage of sampling was wrapped in foil and placed in ZIFLOC® storage bags and labeled with sample identification number for later use.
- This material was temporarily stored on-site in the secured fenced-in decontamination pad area.
- Samples were chosen for dioxin analysis at a later date.
- Plastic bags were then placed in 55-gallon drums for appropriate disposal.



- Drums were sealed when full and marked to identify source and type of material inside the drum.
- Borings were immediately grouted with a cement/bentonite mixture; more grout was added at a later time to account for settling.
- Drilling and sampling equipment were transferred to the decontamination area for cleaning in accordance with procedures outlined in the Project Sampling Plan (Radian, 1986). Water used for cleaning and decontamination procedures was drummed and disposed of at a later date.

The sampling for POP analyses differed from the above procedure in that all four feet of the borehole were composited to compose one sample from each borehole. The compositing involved:

- Recording a geologic description of the core.
- Cutting the screened and trimmed core lengthwise into quarters, then dividing each length into quarters, then dividing each length into approximately a dozen "chunks"; and
- Chunks of core material were selected to represent the core throughout its two foot length.

A sample was selected for dioxin analyses. The sampling proceeded as follows:

- ZIPLOC® storage bags were opened, foil was unwrapped, and selections of core material were made to consistently represent the core throughout its 2 foot length.

### 3.2.3 Analytical Methods and Procedures

All samples were screened for volatile organics when brought to the surface using an HNu analyzer and the readings were recorded in Appendix C-2. The correlation between HNu readings and TCE concentrations are plotted in Appendix C-3. Of the total 37 samples, 10 samples representing 6 shallow boreholes showed a positive HNu response. In addition, two shallow boreholes also showed a positive HNu response within the boreholes themselves.

- All 36 samples were analyzed for PCBs.
- Eighteen samples were analyzed for TCE, based on HNu response; wherever there was no response, samples were chosen based on proximity to former industrial activity and spills, drainage, downgradient location and upgradient background.
- Four composite samples were analyzed for POP; samples were chosen on the basis of a relatively high response to HNu and/or proximity to former industrial activity which may have resulted in spills.
- One sample was analyzed for dioxin based on the relatively high amounts of PCBs detected in the sample.

Appendix C-4 summarizes the analytical methods and preservation requirements for shallow soil borings.

#### 3.2.4 Results and Data Analysis

This section provides data and discussions of results from the shallow boring program. Unlike the surface soil program, this section does not include a comparison with the previously collected data. Previous investigations provided only two data points for shallow boring data, and from these two points, the depth of the boreholes is unknown.

A discussion of PCB and TCE data collected in this program follows:

##### Polychlorinated Biphenyls (PCBs)

PCB values for shallow boring samples are summarized in Table 3-5, and their distribution is illustrated in Figure 3-3.

No PCB contamination is noted in the shallow boreholes located in Area 1 (B-1, B-2, and B-3). This is consistent with surface soil data and operating history of the site. Boreholes B-4 thru B-10 in Area 2 show a wide range of values. The lowest value 0.050 ppm occurs in B-8;ST-2 (2 to 4 feet) and the highest value (220 ppm) in Borehole B-6;ST-1 (the 0 to 2 foot interval). A nearby borehole, B-9;ST-1, also shows high values (137.3 ppm) in the

TABLE 3-5  
POLYCHLORINATED BIPHENYLS (PCB) DATA

Shallow Boring Soil Samples

<u>Sample Identification</u>	<u>Depth (feet)</u>	<u>Value (ppm)</u>
B1;ST-1*	0-2	N.D.
B1;ST-2	2-4	N.D.
B2;ST-1	0-2	N.D.
B2;ST-2	2-4	N.D.
B3;ST-1	0-2	N.D.
B3;ST-2	2-4	N.D.
B4;ST-1	0-2	0.25
B4;ST-2	2-4	0.31
B5;ST-1	0-2	4.3
B5;ST-2	2-4	0.2
B6;ST-1	0-2	220
B6;ST-2	2-4	2.1
B7;ST-1	0-2	0.81
B7;ST-2	2-4	3.48
B8;ST-1	0-2	0.91
B8;ST-2	2-4	0.05
B9;ST-1	0-2	137.3
B9;ST-2	2-4	0.28
B10;ST-1	0-2	1.4
B10;ST-2	2-4	N.D.
B11;ST-1	0-2	1.7
B11;ST-2	2-4	0.095
B12;ST-1	0-2	2.44
B13;ST-1	0-2	0.08
B13;ST-2	2-4	0.35
B14;ST-1	0-2	25.2
B14;ST-2	2-4	3.67
B15;ST-1	0-2	17
B15;ST-2	2-4	0.93
B16;ST-1	0-2	1.889
B16;ST-2	2-4	0.52
B17;ST-1	0-2	N.D.
B17;ST-2	2-4	N.D.
B18;ST-1	0-2	N.D.
B18;ST-2	2-4	N.D.
B19**		N.D.

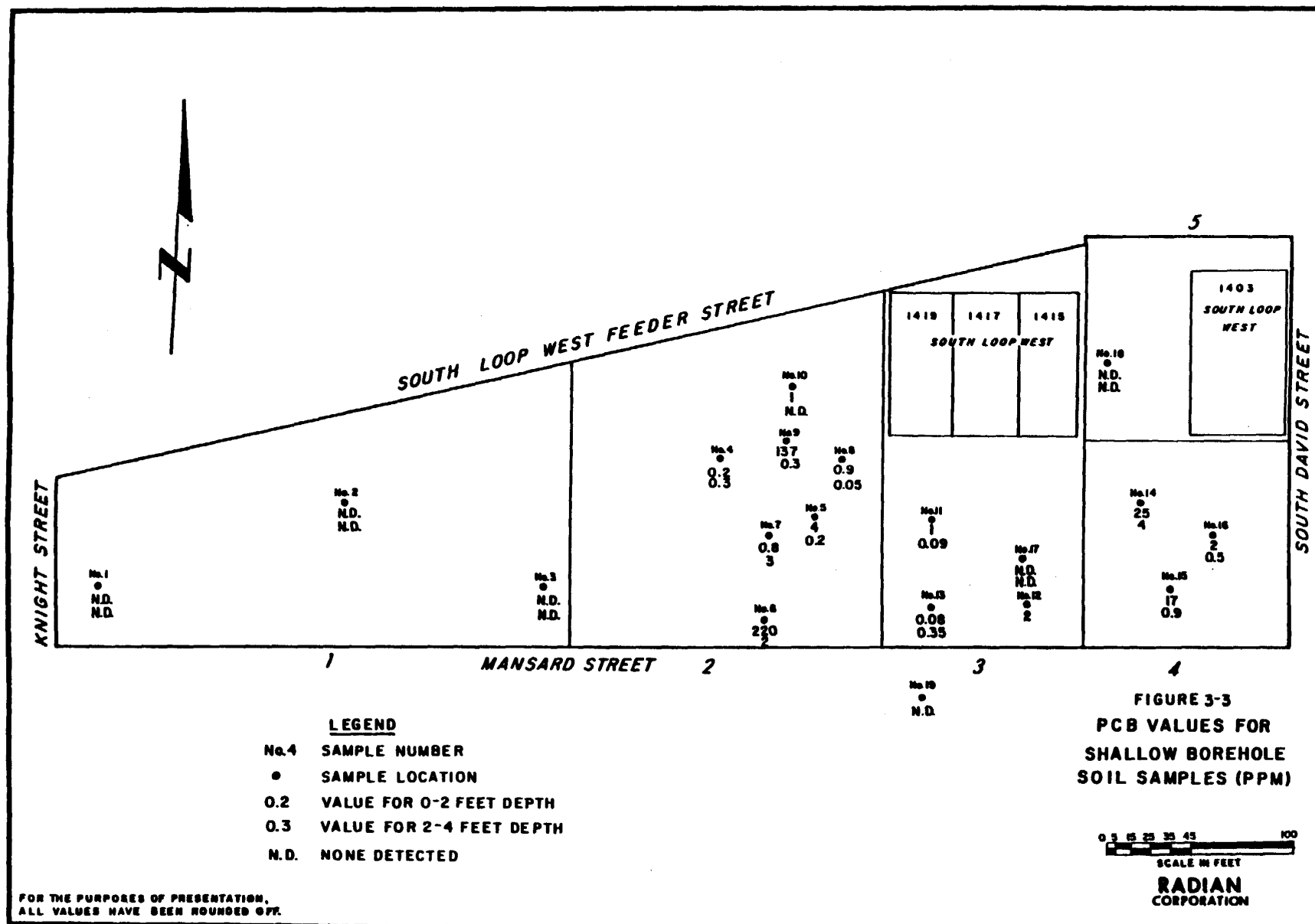
\* The designation "B1" refers to shallow Borehole Number 1. The uppermost interval (0 to 2 feet) is with a Shelby tube (ST) and labeled ST-1. The next interval (2 to 4 feet) is collected with a Shelby tube (ST) and labeled ST-2. Each location is plotted on Figure 3-4 as "No. 1" and so forth.

\*\* Mansard Road composite

ND - Not Detected

Note: Shallow borehole B-12;St-2 exceeded laboratory holding times for analyses and therefore data results are not listed in this table. The QA/QC report discusses this sample in more detail.

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upper 2 feet. Within five of the seven shallow boreholes in Area 2, PCB values decrease significantly with depth. In the remaining two boreholes, B-4 and B-7, PCB values increase slightly with depth (see Figure 3-3).

In Area 3, PCB values within Boreholes B-11, B-12, and B-13 range from 0.08 to 2.44 ppm. PCB values decrease with depth in Borehole 11 and increase slightly with depth in Borehole 13 (Figure 3-3). No PCBs were detected in Sample No. 17.

Only the uppermost sample from Borehole 12, ST-1, is valid data; therefore, no conclusions can be drawn. The QA/QC report presents a discussion of data from B-12;ST-2.

There are three shallow boreholes in Area 4: B-14, B-15, and B-16. PCB values range from 0.5 (B-16;ST-2) to 25 ppm (B-14;ST-1). In all eight boreholes values decrease significantly with depth (Figure 3-3). No PCBs were detected in a shallow borehole (No. 18) in Area 5.

Data indicates that PCB contamination is extremely spotty and variable spatially. Positive data values above detection limits are confined to Areas 3 and 4 and part of Area 2. These results are similar to those obtained for surface soil samples, where PCBs greater than 25 ppm are limited to Areas 2, 3, and 4. Areas 3 and 4 coincide with property owned by Mr. Lynn and the operations of the Industrial Transformer Company. With respect to depth, it is evident that PCBs are limited to depths of 0 to 2 feet from the surface.

#### Trichloroethene (TCE)

TCE values for shallow borehole samples are summarized in Table 3-6 and their distribution illustrated in Figure 3-4.

There are three shallow boreholes in Area 1: B-1, B-2, and B-3. Only B-3 showed a positive HNu response. It contained 0.005 ppm TCE in the uppermost 2 feet of sample and 0.006 ppm TCE from the 2 to 4 foot depth interval.

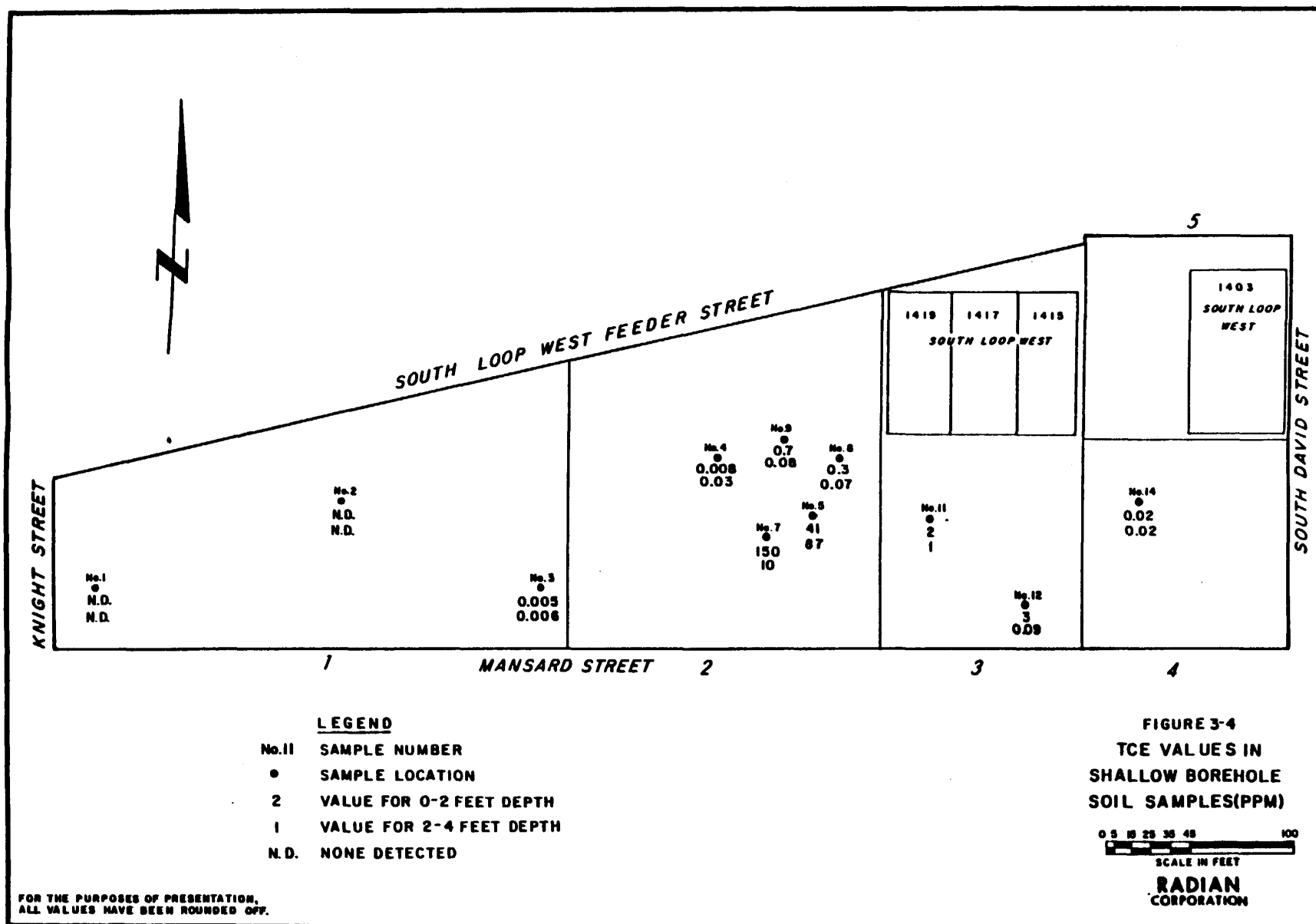
TABLE 3-6  
TRICHLOROETHENE (TCE) DATA

Shallow Boring Soil Samples

<u>Sample Identification</u>	<u>Depth (feet)</u>	<u>Value (ppm)</u>
B3;ST-1*	0-2	0.0051
B3;ST-2	2-4	0.0062
B4;ST-1	0-2	0.0076
B4;ST-2	2-4	0.032
B5;ST-1	0-2	41
B5;ST-2	2-4	87
B7;ST-1	0-2	150
B7;ST-2	2-4	10
B8;ST-1	0-2	0.27
B8;ST-2	2-4	0.074
B9;ST-1	0-2	0.7
B9;ST-2	2-4	0.085
B11;ST-1	0-2	1.7
B11;ST-2	2-4	1
B12;ST-1	0-2	3
B12;ST-2	2-4	0.088
B14;ST-1	0-2	0.022
B14;ST-2	2-4	0.025

\* This designation "B" refers to a shallow boring which is divided into an upper section, 0-2 foot depth, sampled by Shelby tube (ST) and labeled ST-1. A second sample is from the 2-4 foot depth and collected using a Shelby tube (ST) and labeled ST-2. Each location is plotted on Figure 3-5 as "Number 3" and so forth.

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There are five shallow boreholes in Area 2; two samples from each hole (0 to 2 feet and 2 to 4 feet) were analyzed for TCE for a total of ten samples. Seven of the ten samples showed a positive HNu response. Values range from 0.008 ppm (B-4;ST-1) to 150 ppm (B-7;ST-1). In six of the ten samples, values were less than 1 ppm. In the remaining four samples from two boreholes (B-5 and B-7), values ranged from 10 to 150 ppm (Figure 3-4).

In Area 3, there are two shallow boreholes, B-11 and B-12. In B-11, 2 ppm TCE was found in the 0 to 2 foot depth interval and 1 ppm TCE in the 2 to 4 foot depth interval. In B-12, the sample contained 3 ppm TCE in the 0 to 2 foot depth interval and 0.09 ppm in the lower two feet.

In Area 4, there is one shallow borehole, B-14. In the 0 to 2 foot depth interval, there is 0.02 ppm TCE. In the lower, 2 to 4 foot depth interval, there is 0.02 ppm TCE.

In general there is very little TCE in the upper 4 feet of the soil except for a localized area in Area 3. Concentrations appear to be sporadically distributed. There is no definite trend of TCE increasing or decreasing in boreholes.

#### Priority Organic Pollutants (POP)

Four composite samples from Boreholes B-3, B-5, B-7, and B-15 were analyzed for POP. These were composite samples collected from the 4 feet of the shallow boreholes. POP results are summarized in Table 3-7. When applicable, data obtained from POP analysis is compared to the TCE analyses using Method 8010 (SW 846). While these two analytical methods (POP and TCE) tend to confirm the presence and amounts of TCE, the differences in values yielded by the two separate methods are due to inhomogeneity of the soil sample itself and differences in test methods.



TABLE 3-7  
PRIORITY ORGANIC POLLUTANTS (POP) DATA  
Shallow Boring Soil Samples

<u>Sample Identification</u>	<u>Depth (feet)</u>	<u>Compound</u>	<u>Value (ppm)</u>
B-3	0-4	Methylene chloride	0.0082
		Trans-1,2-dichloroethene	0.0015(2)
		Trichloroethene	0.003
B-5	0-4	Trans-1,2-dichloroethene	0.630
		2-Butanone	7.400(1)
		Trichloroethene	37
		Benzene	0.910(1)
		Tetrachloroethene	0.500
B-7	0-4	Acetone	6.000(1)
		Trans-1,2-dichloroethene	8.500
		2-Butanone	15(1)
		Trichloroethene	57
B-15	0-4	Methylene chloride	0.0036
		Acetone	0.110
		Trans-1,2-dichloroethene	0.0036

Notes:

- (1) Detected in reagent blank; background subtraction not performed.
- (2) Estimated value less than minimum detection limit.

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In shallow Borehole B-3, the POP tests reported TCE concentration of 0.0031 ppm, which is very similar to the TCE analysis (Method 8010) (see Table 3-6) where 0.0051 ppm is reported in the upper 2 feet and 0.0062 ppm is reported in the lower 2 feet of the borehole. Methylene chloride, 0.0082 ppm, associated with laboratory procedures, was also present. Another organic compound, trans-1,2-dichloroethene, was detected (0.0015 ppm) in this sample. This chemical is often used as an industrial solvent.

In shallow Borehole No. 5, the POP tests reported 37 ppm TCE; TCE analysis (Method 8010) (see Table 3-6) reported 41 ppm in the upper 2 feet of the borehole and 87 ppm in the lower 2 feet of the borehole. Other organic compounds detected were trans-1,2-dichloroethene (0.630 ppm), 2-butanone (7.4 ppm), benzene (0.910 ppm) and tetrachloroethene (0.5 ppm). These chemicals are also often used as industrial solvents.

In shallow Borehole No. 7, POP tests reported 57 ppm TCE; TCE analysis (Method 8010) (see Table 3-6) reported 150 ppm TCE in the uppermost 2 feet and 10 ppm in the lower 2 feet of the borehole. Other organic compounds detected were acetone at 6 ppm, which is associated with field decontamination procedures (Radian 1986). Trans-1,2-dichloroethene (8.5 ppm) and 2-butanone (15 ppm) were also detected. These two compound are also used as industrial solvents.

In shallow Borehole No. 15, POP analysis detected no TCE. Acetone, found at 0.110 ppm, is associated with field decontamination procedures. Methylene chloride (0.0036 ppm) and trans-1,2-dichloroethene (0.0036 ppm) compose industrial solvents; this may explain their presence in the soils at the ITS site.

#### Dioxins

One sample (B8;ST-1) was analyzed for dioxins, based on a proximity to other samples with high PCB content. Results are reported in Table 3-2; no dioxins were detected.

CONCLUSIONS

A review of the data collected from the surface soil and shallow boring program phase of the RI, as well as information available from other sources, leads to the following conclusions:

- The PCB data from surface soil samples collected by other regulatory agencies are in general consistent with data collected in RI. Such data ranges from less than 1 ppm to 99 ppm. Contamination is limited to Areas 3 and 4 and the eastern edge of Area 2.
- TCE data from surface soil samples collected by other regulatory agencies and by the land owner previous to this RI show more extensive contamination of surface soil. Highest observed concentration was 2862.3 ppm. This is expected as most of these samples were collected while the site was still under active usage. Such contamination is also limited to Areas 3 and 4 and the eastern edge of Area 2.
- PCB contamination of surface soils sampled in this investigation (43 samples) ranges from less than 1 ppm to 220 ppm.
- PCB contamination is principally limited to Areas 3 and 4 and the eastern part of Area 2.
- Three surface soil samples were analyzed for dioxins; none were detected.
- TCE contamination of surface soils sampled in this investigation (4 samples) range from less than 1 ppm to 2 ppm.
- PCB contamination of shallow soil borings ranges from less than 1 ppm to 220 ppm.
- TCE contamination is highly localized and is limited to Areas 3 and 4 and the eastern part of Area 2.
- With respect to depth, PCBs are limited to the upper 2 feet of the soil zone. In general, there is a drastic reduction in PCB concentration from upper 2 foot to lower 2 foot depth.
- PCB contamination is extremely localized in occurrence, but most of the occurrences and the highest degree of contamination are confined to Areas 3 and 4 and the eastern portion of Area 2.
- TCE contamination of shallow borings (18 samples) ranges from less than 1 ppm to 150 ppm.

- There is no definite trend of TCE increasing or decreasing in the shallow boreholes with depth.
- The highest concentration of TCE (150 ppm) was found within shallow borehole No. 7 in Area 2. The portion of this same area contains other relatively high values of TCE as well.
- POP analysis of surface soils and shallow borings indicate only a few organics in minimal concentrations. One can safely state that the primary organic contaminants are PCBs and TCE.

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## SECTION 4

### DEEP SOIL BORING AND MONITOR WELL INSTALLATION PROGRAM

The deep soil boring and monitor well installation programs consist of drilling five deep borings and installing seven monitor wells. Of the seven monitor wells installed, six are in the shallow water-bearing zone and one is in the intermediate water-bearing zone. Of the six shallow monitor wells, three had been installed in borings drilled in the deep boring program while three were installed in borings as part of the monitor well drilling program.

This chapter describes the location, drilling, soil sampling, well installation, and well development procedures used in the RI. Also, included in this chapter is a discussion of chemical and geotechnical analyses, procedures and results.

#### 4.1 SOIL BORING AND MONITOR WELL INSTALLATION PROCEDURES

The locations of deep borings and monitor wells were guided by previous data and potential locations of contaminants as inferred from previous industrial activity. For example, monitor wells in both the uppermost water-bearing zone and in the intermediate zone were located near the old water well at the site. Other shallow monitor wells were located near an old drum storage area where TCE was suspected to have been discharged, in areas showing high concentration of contaminants in the soils, and also in areas away from the industrial activity to establish background conditions.

Five deep soil borings were drilled to depths ranging from 38 to 44 feet. Of the five deep soil borings, three were converted into groundwater monitor wells. Deep boring DB-2 is now monitor well MW-2, deep boring DB-4 is now monitor well MW-5 and deep boring DB-5 is now monitor well MW-7. In addition, four other monitor wells (MW-1, MW-3, MW-4 and MW-6) were drilled at the site. One of these wells, only MW-3 is completed in the intermediate water-bearing zone. The shallow monitor wells, completed in the uppermost

water-bearing zone, reach total depths ranging from 43 to 44 feet while the intermediate monitor well MW-3 reaches a total depth of 99 feet. Thus, a total of two deep borings and seven monitor wells were located on the ITS site at the end of the RI, Phase I, March 1987.

In the shallow wells and deep borings, the sampling plan indicated that soil samples would be collected at 0-1, 2.5-5, 5-7.5, 7.5-9, 10-15, 15-20, 20-25, 25-30, 30-35, and 35-40 foot depths. However, in order to recover a greater percentage of sample from each interval, samples were collected at 0-1, 2.5-4, 5-6.5, and 7.5-9 foot depths. Sampling on five foot centers started at the nine foot depth (instead of ten foot depth as per sampling plans) because of the drilling practice whereby casing is "pushed" from nine to ten feet in order to seat it in the soil. Continuous sampling then started at 9-13, 13-18, 18-23, 23-28, 28-33, and 33-38 feet.

In the intermediate well (MW-3), soil samples were collected at depths 0-5, 5-9, 9-10, 25-26, 54-55.5, 65-66.5, 89-90.5, and 94-95.5 feet for PCB analysis. Near the surface, the upper 10 feet was collected on a more frequent basis because PCBs tend to bind in the organic portion of soil particles and therefore occur with greater frequency in the uppermost soil horizon. The deeper soil horizons were analyzed to delineate any downward migration of contaminants.

All soil samples were analyzed for PCBs. As per the work plans, only limited numbers of soil samples were to be analyzed for TCE. In order to select soil samples for TCE analysis, all samples were screened by the HNu instrument (see Appendix C-2) which detects emissions of volatile organics, and those samples displaying high readings were chosen for laboratory analysis. However, no samples were taken from MW-1 and MW-6 because of the distance away from the original industrial activity. Also, samples were not collected from DB-2; MW-2 because of its proximity to MW-3, which was sampled.

The following paragraphs provide further details on drilling of deep borings and conversion of deep borings to monitor wells and installation of monitor wells.

#### Drilling for Deep Borings

The procedure used in the drilling of the deep borings is as follows:

- Vegetation was removed using a clean, hand-held rake.
- A 6 inch borehole was advanced with a steam-cleaned flight auger and then reamed with a 10 inch hollow-stem auger. The borehole was advanced to a total depth of 9 feet.
- After the auger had drilled to the sample depth, a clean Shelby tube sampler was advanced inside the auger to a depth of 1.5 feet below the auger. The uppermost 9 feet was sampled using a Shelby tube at the following intervals: 0-1, 2.5-4, 5-6.5, 7.5-9 feet.
- An 8 inch I.D. of 10 feet length PVC protective surface casing was placed in the 10 inch borehole at a depth of 9 feet and then pushed 1 foot to "seat" it in the clay. The hole was grouted from bottom to top. The grout was allowed to set for 24 hours.
- A 6 inch borehole was resumed at 9 feet and advanced by hollow-stem auger (6 inch O.D.) through the first saturated zone. Continuous sampling, in 5 foot segments, was utilized at depths greater than 9 feet.
- While drilling a 5 foot interval with a flight auger, the core barrel inside the flight auger collected samples. Thus, sampling occurred simultaneously with drilling.
- All samples were extruded and trimmed, and a composite sample was placed in a container and covered. An HNu analyzer "wand" was inserted for 30 seconds, and the readings were recorded. The sample in this container was then discarded.
- The core was quartered in a lengthwise fashion, and a composite sample was removed from the core and placed in a clean labeled container and appropriately stored prior to shipment to the laboratory. Chain-of-custody forms were filled out for each sample.

- About six inches of core, more if available, were wrapped in aluminum foil and stored in labeled ZIPLOC® storage bags. These samples were to be available for dioxin and geotechnical analysis. Samples were stored on-site in the secured decontamination area.
- Remaining cuttings and drilling waste material from each boring were placed in drums for appropriate disposal. The drums were sealed and identified as to source and nature of materials.
- All drilling equipment underwent proper decontamination processes before and after completion of each borehole as specified in the Project Sampling Plan (Radian, 1986).

A boring was terminated provided one or both of the following conditions were met:

1. The boring had penetrated the uppermost water-bearing zone (shallow aquifer) and several feet into the first underlying clay unit, and
2. The boring had penetrated the uppermost water-bearing zone and the last two samples collected contained no detectable volatile organics using the HNu.

#### Conversion of Deep Soil Boring to a Monitor Well

Procedures for converting a deep soil boring (that had been sampled) to a shallow monitor well are described below. The description given below proceeds from the completion of the deep soil boring, i.e., the borehole was advanced with a six inch O.D. hollow-stem auger through the bottom of the uppermost aquifer and at least two to five feet into the underlying clay zone.

- Well components as specified and diagrammed in the Well Completion Forms (Appendix D-1), including all screens and casing, were steam-cleaned before installation.
- Casing and screen were lowered through the boring. The borehole annulus was packed with clean No. 2 sand poured from total depth to about two feet above the top of the screen. Bentonite pellets were added to produce a one to two foot seal. Cement/bentonite grout was then pumped into the borehole annulus from the top of the seal to the land surface and allowed to set for 24 hours.



- An external protective housing of 4 foot length and 6 inch I.D. was cemented into place. Grout was poured inside and outside the protective housing to prevent rainwater from leaking down around the casing. Then a locking cover and padlock were installed on the protective housing.

#### Construction of Shallow Monitor Wells

Construction procedures for shallow monitor wells that have been sampled by Shelby tube, core barrel or split-spoon apparatus (monitor wells MW-1, MW-2, MW-5, and MW-7) are the same as those outlined for conversion of deep borings to monitor wells. Construction procedures for shallow monitor wells that have not been sampled, except for auger cuttings (monitor wells MW-4 and MW-6) are the same as those outlined earlier, with the exception of the following:

- A center plug was placed on the bottom of the hollow-stem auger as drilling proceeded, preventing the collection of soil cores.

#### Construction of the Intermediate Well

The procedures for intermediate monitor well construction were as follows:

- Vegetation was removed using a hand-held rake.
- A 14 inch borehole was advanced using a hollow-stem auger.
- A 12 inch PVC surface casing was installed from surface to 10 feet and grouted in place to prevent contaminant migration through the borehole. The grout was allowed to set for 24 hours before drilling proceeded.
- A continuous flight auger was used to advance the borehole through the uppermost aquifer.
- Composite samples were collected from the flight augers at depths of 0.5, 5-9, 9-10, and 25-26 feet after screening by the HNu analyzer and readings then recorded (Appendix C-2).

- An eight inch PVC surface casing was installed from the surface to a depth of 44 feet. The hole was grouted from bottom to top. The grout was allowed to set for 24 hours.
- A six inch hollow-stem auger was used to drill out from under the casing; a center plug was used to prevent soil material from advancing up the hollow-stem auger.
- At the sampling depths (54, 65, 89, and 94 feet), the center plug was pulled out of the hole, a split spoon sampler was advanced down the hole, pushed 1.5 feet and then pulled out of the hole with the sample
- Samples were extruded and trimmed, and a composite sample was placed in a container and covered. An HNu analyzer was inserted for 30 seconds, and the readings were recorded (Appendix C-2).
- The sample in this container was then discarded.
- About six inches of core, more if available, were wrapped in aluminum foil and stored in labeled ZIPLOC® storage bags. These samples were to be available for dioxin and geotechnical analysis.
- Samples were stored on-site in the secured decontamination area.
- The center plug was replaced at the bottom of the hole and drilling resumed to the next interval where the procedure was repeated.
- This six inch borehole was advanced through the next aquifer to a total depth of 99 feet.
- Well components as specified and diagrammed in the Well Completion Forms (Appendix D-2) were steam-cleaned before installation. Well construction details are listed in Appendix D-1.
- Casing and screen were lowered through the borehole. The borehole annulus was packed with clean No. 2 sand poured from total depth to eight feet above the screen. Bentonite pellets were added for a five foot seal. Cement/bentonite grout was pumped into the borehole annulus from the top of the seal to the land surface and allowed to set for 24 hours.
- The protective housing (four foot length) was cemented into place. Grout was poured inside and outside the protective housing to prevent water from leaking down around the casing, then a locking cover and padlock were placed on the protective housing.
- All cuttings and fluids were placed in 55-gallon drums, which were sealed and labeled.

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### Well Development Procedures

All shallow and intermediate wells were developed using the following procedures:

- Depth to water level from top of casing was measured using a "popper" tape.
- Volume of casing\* and sandpack\*\* were calculated, added together and multiplied by 3. This was the amount of water to be removed from the aquifer.
- Compressed air was used to develop each well; dedicated lengths of hose carried the produced water from the wellbore to a 55-gallon drum. A small amount of glue was used to glue valve and hose apparatus together.
- Inducing compressed air in roughly 30-second "blasts" was necessary to produce water and then allow the well to recharge for a period of time before inducing another "blast" of compressed air.
- Temperature, salinity and electrical conductivity were measured until the three readings stabilized and conductivity measurements were within 10 percent (Appendix D-2) of the previous measurement.

000003

### 4.2 SITE GEOLOGY

In a regional context, the ITS site is situated in interdistributary clays and is located about a mile north of a Pleistocene distributary channel belt. An offshoot from this distributary channel belt extends within a quarter of a mile of the site.

Description of site geology is derived from geologic logs of the deep borings generated at the ITS site during the RI. All lithologies at the site are unconsolidated. Detailed lithologic descriptions (including boring logs)

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\* Volume (casing) =  $\pi r^2$  \* height of water column above sandpack, where r = radius of casing.  
\*\* Volume (sandpack) =  $\pi r^2$  \* height of sandpack, where r = radius of casing.

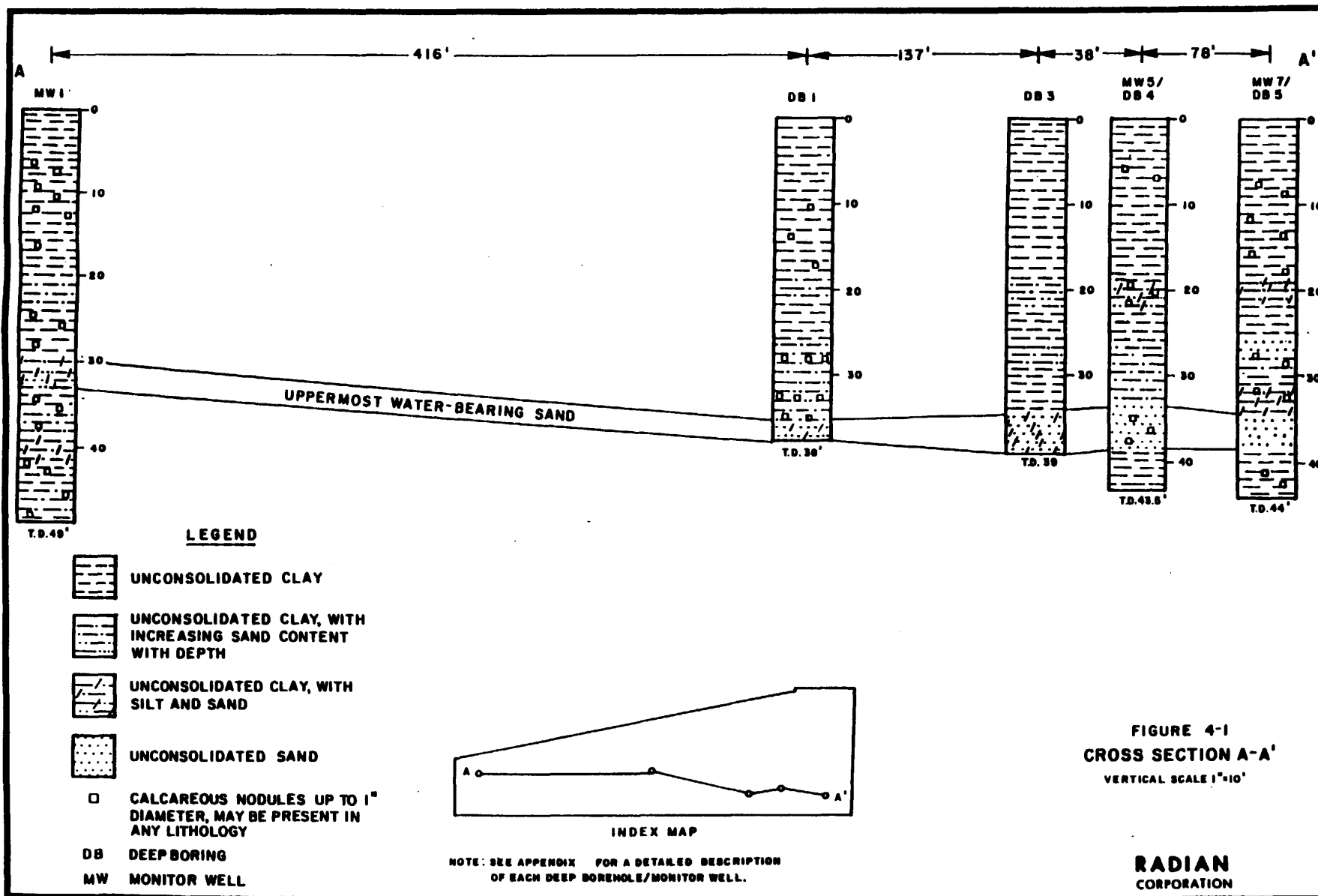
are recorded in Appendix B-2. East-west and north-south cross-sections illustrate the site stratigraphy in these two directions (Figures 4-1 and 4-2).

The uppermost stratigraphic unit consists of clay, extending from the surface down to the uppermost aquifer, the top of which ranges from 30 to 34 feet below ground surface. This clay varies in color from brownish-gray to gray in the uppermost few feet to a stiff red clay, typically mottled gray, tan and brown. Iron-oxide pockets and nodules are common down to 18 feet. Calcareous nodules sporadically occur within this horizon.

A thin, two to three foot layer of silty, sandy clay interrupts the uppermost clay at 18 to 21 feet of depth across the east portion of the site (see cross-section A-A', Figure 4-1). In MW-1, this layer is mostly clay with very small amounts of sand. Increasing amounts of sand occur in DB-3 and silt appears with the sand in both DB-4/MW-5 and DB-5/MW-7. This same zone of sandy (silty) clay is also shown in cross-section B-B' (Figure 4-2).

At 21 feet of depth, the lithology returns to stiff reddish clay, often mottled gray or orange. Calcareous nodules typically occur in a zone at 27 feet and below. Sandy or silty clay is also observed at 27 feet and below in deep bores (see cross-section A-A'). Only in DB-5/MW-7 does this layer become a one foot thick fairly clean sand.

The uppermost water-bearing sand is a light gray-tan to white, clayey sand to sandy clay, characterized by fine to very fine grain size particles and containing a few calcareous nodules. This sand was probably deposited as the result of levee or crevasse splay from a nearby Pleistocene fluvial channel (Figure 2-2). As a consequence, sand lenses are probably localized. This interpretation as a crevasse splay is based on two criteria: the proximity of the sand deposit to a Pleistocene distributary system and the textural variations of the sand unit across the site. The uppermost aquifer varies in thickness from two feet in MW-1 to six feet in MW-2/DB-2. The amount of finer



material contained within the unit (see Figure 4-1, cross-section A-A') decreases from approximately 50 percent in MW-1 to less than 10 percent in MW-7 on the opposite end of the site. Apparently the crevasse splay deposit is nearest its source at MW-7. Since crevasse splay deposits are failed attempts of a river to establish a delta distributary, there is little probability of this sand deposit connecting with the source channel.

The uppermost water-bearing sand is separated from the next lower, "intermediate" water-bearing sand by a stiff clay, which varies in color from green to gray-white and contains iron-oxide pockets and iron staining. Calcareous nodules occur sporadically in this layer.

The intermediate water-bearing zone (approximately 84 to 94 feet) consists of a red, clayey, silty sand. Underlying the aquifer are stiff reddish brown clay, mottled blue-green, iron-oxide pockets and occasional silty clay pockets or stringers.

#### 4.3 ANALYTICAL PARAMETERS AND PROCEDURES

The drilling and monitor well construction program as described previously yielded in a total of 62 soil samples. All samples were screened for volatile organics using a HNu analyzer, and the measurements were recorded. HNu measurements are given in Appendix C-3. In meeting with the sampling plan, the samples were analyzed to according to the following scheme:

- Sixty-two\* samples were analyzed for PCBs.
- Four samples showing high HNu readings were analyzed for TCE. Samples from DB-2 were originally chosen for analysis but due to insufficient refrigeration were not used. These samples were replaced by samples from DB-3.
- One sample showing high HNu readings was analyzed for POP.

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\*Monitor well samples MW-3/S-1, MW-3/S-2 and MW-3/S-3 exceeded laboratory holding times for analysis and therefore, data results are not presented in this discussion. The QA/QC report discussed these samples in more detail.

Additionally, in order to provide the geotechnical data which may be necessary for the selection and design of remediation efforts, nine samples were chosen for geotechnical analyses, which included grain size analysis and determination of Atterberg limits (plastic and liquid).

As part of the QA/QC program, a total of six blank (trip) samples were analyzed for PCBs, three (trip) samples for TCE and one (trip) sample for POP analysis. A discussion of the results is presented in a separate QA/QC report.

Appendix C-4 summarizes the analytical methods and procedures and the sample preservation and handling requirements.

#### 4.4 RESULTS AND DATA ANALYSIS

##### Polychlorinated Biphenyls (PCBs)

Table 4-1 summarizes PCB data, and Figure 4-3 shows the distribution of PCBs in soil samples from deep borings and monitor wells. The highest values of PCBs in deep boring DB-1 were reported from the uppermost foot (0 to 1 foot), at 20 ppm and decreasing to less than one ppm in the next depth interval of 2.5 to 4 foot. PCBs were also observed at less than 0.1 ppm at the depth of 7.5 to 9 foot and less than 0.2 ppm at the depth of 23 to 28 foot. Deep boring DB-2, which now contains monitor well MW-2, showed values of less than one ppm that decreased with depth, in the uppermost nine feet of the soil horizon. A single value of 0.16 ppm (PCBs) was also detected at 18 to 23 feet. Deep boring DB-3 showed a high value of 350 ppm PCBs in the uppermost foot (0 to 1 foot). The values then decreased to 0.2 ppm in the 2.5 to 4 foot horizon and finally to 0.05 ppm at 5 to 6.5 feet. No detectable amounts of PCBs were reported at other depths. Deep boring DB-4, now containing monitor well MW-5, reported values at or less than one ppm at various depths up to nine feet.

Deep boring DB-5, converted to monitor well MW-7, showed two values of PCBs. A value of 1.7 ppm was documented in the uppermost one foot interval, and a sharply lower value of 0.05 ppm was reported for the 5 to 6.5 foot depth.

TABLE 4-1  
POLYCHLORINATED BIPHENYLS (PCBs) DATA

Deep Boring Soil Samples

<u>Sample Identification</u>	<u>Depth (feet)</u>	<u>Horizon</u>	<u>Value (ppm)</u>
DB-1;ST-1	0-1	upper clay	20
DB-1;ST-2	2.5-4	upper clay	0.65
DB-1;ST-3	5-6.5	upper clay	N.D.
DB-1;ST-4	7.5-9	upper clay	0.07
DB-1;CM-1	9-13	upper clay	N.D.
DB-1;CM-2	13-18	upper clay	N.D.
DB-1;CM-3	18-23	upper clay	N.D.
DB-1;CM-4	23-28	upper clay	0.14
DB-1;CM-5	28-33	upper clay	N.D.
DB-1;CM-6	33-38	shallow aquifer	N.D.
DB-2;ST-1*	0-1	upper clay	0.78
DB-2;ST-2	2.5-4	upper clay	0.79
DB-2;ST-3	5-6.5	upper clay	0.13
DB-2;ST-4	7.5-9	upper clay	0.48*
DB-2;CM-1	9-13	upper clay	N.D.
DB-2;CM-2	13-18	upper clay	N.D.
DB-2;CM-3	18-23	upper clay	0.23
DB-2;CM-4	23-28	upper clay	N.D.
DB-2;CM-5	28-33	upper clay	N.D.
DB-2;CM-7	38-43	shallow aquifer	N.D.
* Deep Boring 2 converted to Monitor Well 2.			
DB-3;ST-1	0-1	upper clay	350
DB-3;ST-2	2.5-4	upper clay	0.2
DB-3;ST-3	5-6.5	upper clay	0.05
DB-3;ST-4	7.5-9	upper clay	N.D.
DB-3;CM-1	9-14	upper clay	N.D.
DB-3;CM-2	14-19	upper clay	N.D.
DB-3;CM-3	19-24	upper clay	N.D.
DB-3;CM-4	24-29	upper clay	N.D.
DB-3;CM-5	29-34	upper clay/ shallow aquifer	N.D.
DB-3;CM-6	34-39	shallow aquifer	N.D.
DB-4;ST-1*	0-1	upper clay	0.202
DB-4;ST-2	2.5-4	upper clay	1.03
DB-4;ST-3	5-6.5	upper clay	N.D.
DB-4;ST-4	7.5-9	upper clay	0.088

Key

ND - Not Detected      DB - Deep Boring      ST - Shelby tube samples  
CM - Core barrel samples      S - Auger cutting samples      SB - Split spoon samples



TABLE 4-1 (Cont'd)  
POLYCHLORINATED BIPHENYL (PCB) DATA

Deep Boring Soil Samples

<u>Sample Identification</u>	<u>Depth (feet)</u>	<u>Horizon</u>	<u>Value (ppm)</u>
DB-4;QM-1	9-13.5	upper clay	N.D.
DB-4;QM-2	13.5-18.5	upper clay	N.D.
DB-4;QM-3	18.5-23.5	upper clay	N.D.
DB-4;QM-4	23.5-28.5	upper clay	N.D.
DB-4;QM-5	28.5-33.5	upper clay	N.D.
DB-4;QM-6	23.5-38.5	shallow aquifer	N.D.

\* Deep Boring 4 converted to Monitor Well 5

DB-5;ST-1*	0-1	upper clay	1.7
DB-5;ST-2	2.5-4	upper clay	N.D.
DB-5;ST-3	5-6.5	upper clay	0.05
DB-5;ST-4	7.5-9	upper clay	N.D.
DB-5;QM-1	9-13	upper clay	N.D.
DB-5;QM-2	13-18	upper clay	N.D.
DB-5;QM-3	18-23	upper clay	N.D.
DB-5;QM-4	23-28	upper clay	N.D.
DB-5;QM-5	28-33	upper clay	N.D.
DB-5;QM-6	33-38	shallow aquifer	N.D.

\* Deep Boring 5 converted to Monitor Well 7

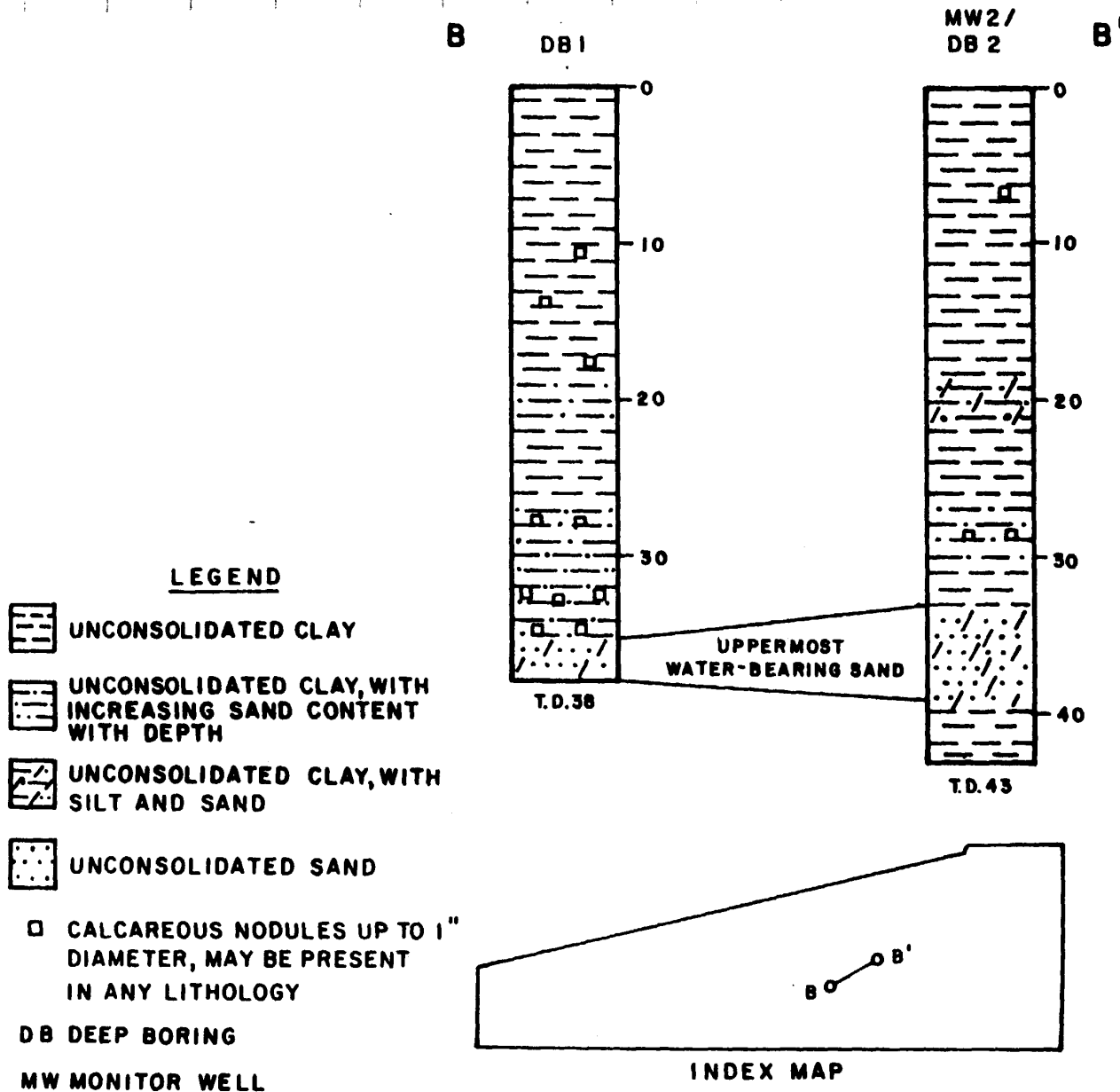
Monitor Well Soil Samples

MW-1;ST-3	4-6	upper clay	N.D.
MW-1;ST-6	10-12	upper clay	N.D.
MW-1;ST-8	14-16	upper clay	N.D.
MW-1;ST-11	20-22	upper clay	N.D.
MW-3;S-4	25-26	upper clay	N.D.
MW-3;S-5	54-55.5	intermediate clay	N.D.
MW-3;S-6	65-66.5	intermediate clay	N.D.
MW-3;S-7	89-90.5	intermediate aquifer	N.D.
MW-3;S-8	94-95.5	intermediate aquifer/ lower clay	N.D.
MW-4;S-1	0-5	upper clay	N.D.
MW-4;S-2	5-9	upper clay	N.D.
MW-6;S-1	0-5	upper clay	1.3
MW-6;S-2	5-9	upper clay	N.D.

Key

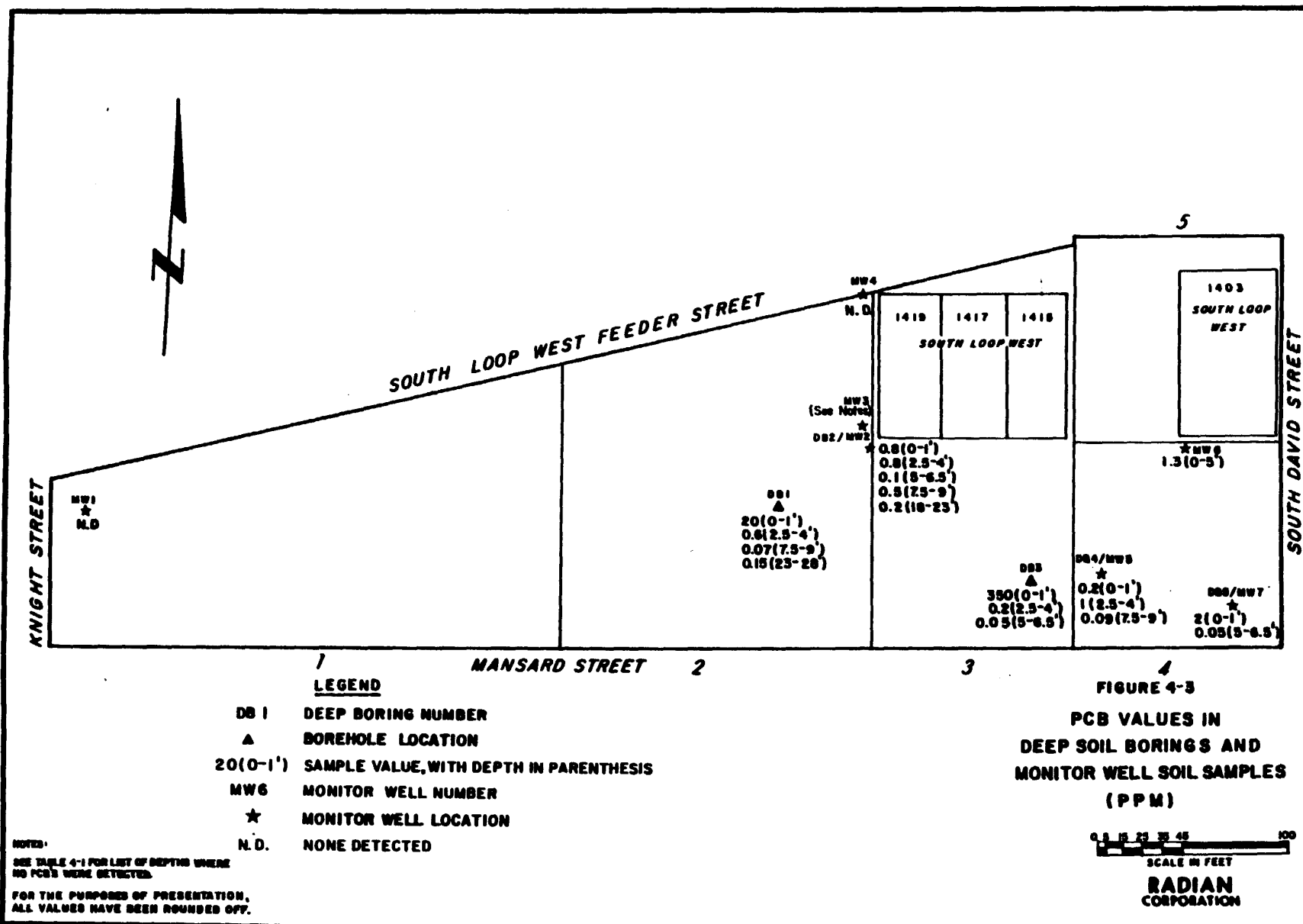
ND - Not Detected      DB - Deep Boring      ST - Shelby tube samples  
QM - Core barrel samples      S - Auger cutting samples      SB - Split spoon samples

Note: Monitor well samples MW-3;S-1, MW-3;S-2 and MW-3;S-3 exceeded laboratory holding times for analysis and therefore, data results are not listed in this table. The QA/QC report discusses these samples in more detail.



**FIGURE 4-2**  
**CROSS SECTION B-B'**  
VERTICAL SCALE 1"=10'

**RADIAN**  
CORPORATION



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Monitor well MW-1 was sampled at depths of 4-6, 10-12, 14-16, and 20-22 feet. None of the samples showed any detectable quantities of PCBs. No PCBs were reported in monitor well MW-4 which was sampled throughout the entire depth of 95.5 feet. Monitor well MW-6 contained 1 to 3 ppm PCBs in the first samples obtained from the depth of 0 to 5 feet.

PCB distribution within the monitor wells and deep borings shows the same pattern as noted earlier. PCB concentrations tend to be confined to the uppermost soil layers (upper two foot depth) and decrease rapidly with depth. While PCBs have been detected at greater depths in minimal concentrations (1 ppm or less), these occurrences are sporadic and are separated by soil horizons containing no detectable amounts of PCBs.

#### Trichloroethene (TCE)

TCE data for deep boring and monitor well soil samples is listed in Table 4-2 and illustrated in Figure 4-4. A number of the samples responded in a positive manner to the HNu (See Appendix C-2) indicating the presence of volatile organics, but following the specifications of the sampling plan, only a limited number of samples were analyzed for TCE.

No soil samples were selected for TCE analysis from MW-1, DB-1, or DB-6 because of lack of response or relatively low response when samples were analyzed by the HNu. In other deep borings/monitor wells, samples from selected horizons were analyzed for TCE; however, intervening clay layers may also show the presence of TCE upon analysis.

In DB-3, 18 ppm TCE was reported in samples from a depth of 24 to 29 feet while 40 ppm was reported in samples from the 34 to 39 foot depth (uppermost water-bearing zone). A similar pattern of TCE contamination was observed in DB-4/MW-5, i.e., 5.7 ppm of TCE at the 23.5 to 28.5 foot depth and 43.0 ppm at the depth of 33.5 to 38.5 foot (uppermost water-bearing zone).

TABLE 4-2  
TRICHLOROETHENE (TCE) DATA

Deep Boring Soil Samples

<u>Sample Identification</u>	<u>Depth (feet)</u>	<u>Horizon</u>	<u>Value (ppm)</u>
DB-3;QM-4	24-29	upper clay	18
DB-3;QM-6	34-39	shallow aquifer	40
DB-4;QM-4	23.5-28.5	upper clay	5.7
DB-4;QM-6	33.5-38.5	shallow aquifer	43
DB-5;QM-4	23-28	upper clay	5.1
DB-5;QM-6	33-38	shallow aquifer	0.0077

Deep Boring 5 converted to Monitor Well 7

Monitor Well Soil Samples

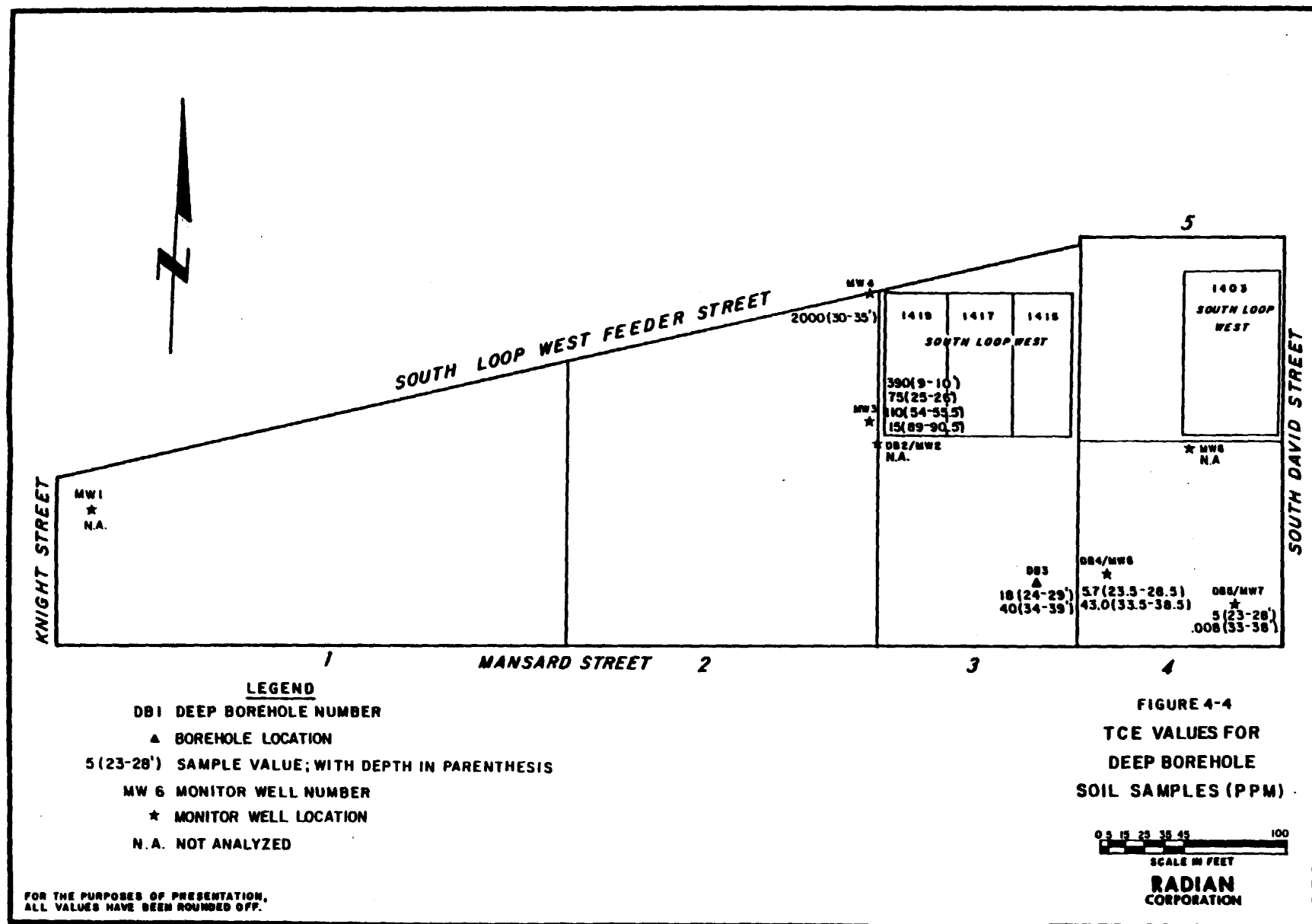
MW-3;S-3	9-10	upper clay	390
MW-3;S-4	25-26	upper clay	75
MW-3;SB-1	54-55.5	intermediate clay	110
MW-3;SB-3	89-90.5	intermediate aquifer	15
MW-4;S-4	30-35	upper aquifer	2000

Key

DB - Deep Borehole  
MW - Monitor Well  
QM - Core barrel samples  
S - Auger cutting samples  
SB - Split barrel samples

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Within DB-5, now MW-7, there are two TCE values: 5 ppm was reported at 23 to 28 feet (above the shallow, water-bearing zone) and approximately 8 ppm was reported at 33 to 38 feet, representative of the uppermost water-bearing zone.

Monitor well MW-3 showed significant amounts of TCE: 390 ppm at 9 to 10 feet, 75 ppm at 25 to 26 feet (both samples were located above the shallow, water-bearing zone), 110 ppm at 54 to 55.5 feet and 15 ppm at 89 to 90.5 feet (the latter sample being within the intermediate water-bearing sand). No samples were collected for TCE analysis from the clay underlying the intermediate aquifer or water-bearing sand.

In MW-4, a soil sample collected from 30 to 35 feet (the uppermost water-bearing zone) contained 2000 ppm TCE.

TCE distribution within the deep subsurface soils is apparently limited to Areas 2, 3, and 4, coinciding with previously discussed property lines and work areas. Values of TCE contamination tend to be lower at the surface (probably due to the volatility of trichloroethene). TCE has been observed in clays overlying the first aquifer and in clays underlying the first and second aquifers.

#### Priority Organic Pollutants (POP)

Table 4-3 lists the results of the POP analyses. The POP analyses indicated the presence of 240 ppm TCE at a depth of 18 to 23 feet (above the uppermost water-bearing zone) in DB-2, which is now MW-2. The sample from MW-3/SB-1 at a depth of 54 to 55.5 feet (intermediate clay), showed 12 ppm TCE; TCE analysis of a separate soil sample from the same depth indicated 110 ppm TCE.

Other organic compounds observed in significant concentrations are 2-butanone and acetone, which may be associated with sample handling procedures. Phthalates and tetrachloroethene have also been observed.

TABLE 4-3  
PRIORITY ORGANIC POLLUTANTS (POP) DATA

Deep Boring Soil Samples

<u>Sample Identification</u>	<u>Depth (feet)</u>	<u>Compounds</u>	<u>Value (ppm)</u>
MW-2/DB-2;CM-3	18-23	Di-n-butylphthalate	2.3 <sup>(1)</sup>
		Bis(2-ethylhexyl)phthalate	0.24 <sup>(1)</sup>
		Acetone	29 <sup>(1)</sup>
		2-Butanone	70 <sup>(1)</sup>
		Trichloroethene	240
		Tetrachloroethene	5.9

Monitor Well Soil Samples

MW-3;SB-1	54-55.5	Di-n-butylphthalate	0.82
		Bis(2-ethylhexyl)phthalate	0.47 <sup>(1)</sup>
		2-Butanone	6.6 <sup>(1)</sup>
		Trichloroethene	12

Key

DB - Deep boring  
MW - Monitor well  
CM - Core barrel samples  
SB - Split barrel samples  
EB - Field blank

(1) - Detected in Reagent Blank; background subtraction not performed.



#### 4.5 GEOTECHNICAL ANALYSIS OF SOIL SAMPLES

Nine soil cores were selected for geotechnical characteristics of the underlying materials at the ITS site. Tests included Atterberg limits (plastic limit and liquid limit) and grain size analysis. These parameters are explained in Appendix B-1. The samples were selected to be representative of the following matrices: the clays overlying the first aquifer, material from the first aquifer, clay material underlying the aquifer, material from the second aquifer and material underlying the second aquifer. In addition to providing vertical distribution information, another consideration for sample selection was to provide for spatial distribution.

##### 4.5.1 Sample Type, Location and Number

Table 4-4 summarizes the lithology, depth, horizon, and various tests performed on each soil sample.

Two samples were chosen from MW-1, in Area 1, at the furthest western location. A sample was chosen from the clays above the shallow water-bearing zone (20 to 22 feet), and one sample was chosen from the uppermost water-bearing zone (33.5 to 38.5 feet).

One sample was chosen from DB-2/MW-2, in Area 2, approximately in the middle of the ITS site. The sample was obtained from clays at the depth of 38 to 43 feet. These clays are located between the upper and the second aquifers.

Three samples were selected from MW-3, in Area 2, also approximately in the middle of the ITS site. These samples came from three areas: the clay horizon separating the two water-bearing zones (65 to 66.5 feet), the intermediate water-bearing zone (85 to 94 feet), and the clay immediately below the intermediate water-bearing zone (94 to 95.5 feet).

One sample was obtained from DB-3, in Area 3, immediately above the shallow water-bearing zone at 29 to 34 feet.

Two samples were selected from DB-4/MW-5, in Area 4, which is furthest to the east. One sample was a clay sample from a depth of 8 to 18 feet above the shallow water-bearing zone, and the other sample was obtained from a depth of 33.5 to 38.5 feet. This depth comprises the shallow water-bearing aquifer at that location and can be compared to the aquifer at MW-1.

#### 4.5.2 Results and Data Analysis

Descriptions of geotechnical samples are recorded in Table 4-4, and the analytical results are summarized in Table 4-5. Discussion will move from samples at shallow depths to those at greater depths.

The three samples collected above the uppermost water-bearing zone exhibit very similar plastic limits (20, 18 and 16, in order of increasing depth) when samples exhibit plastic behavior. The liquid limits vary from 50 to 30 to 33 (in order of increasing depth) when samples exhibit liquid behavior. The samples from 13 to 18 feet and 20 to 22 feet are composed of 90% or greater fine particles of silt and clay size (below 0.07 mm) (Table 4-5). Larger particles consist of calcareous nodules and medium and fine-grained sands. The sample collected from 29 to 34 feet (immediately above the uppermost water-bearing zone) contains about 70% silt and clay and a slightly larger percentage of fine sand (Table 4-5).

The two samples collected from the uppermost water-bearing zone differ in the amount of sand. The sample from monitor well MW-1/ST-17 (at the far west end of the site) contains 58% sand and 42% silt and clay-sized material. A higher percentage of sand (70%) is contained in the sample from DB-4/CM-6A, located on the eastern edge of the site (Table 4-5).

The next two samples, DB-2/CM-7A and MW-3/SB-2, were collected from the depths of 38 to 43 feet and 65 to 66.5 feet respectively. Both were obtained from the clay underlying the uppermost water-bearing zone. Both

TABLE 4-4  
GEOTECHNICAL SAMPLE DESCRIPTION AND LOCATION

<u>SAMPLE IDENTIFICATION</u>	<u>LITHOLOGY</u>	<u>DEPTH (FEET)</u>	<u>HORIZON</u>	<u>TESTS PERFORMED*</u>
DB4 QM2B	Tan, brown and grey mottled stiff plastic clay with calcareous nodules	13-18'	above the uppermost aquifer	grain size analysis, Atterburg limit
MW1 ST11	Interbedded red stiff clay and sandy clay	20-22'	above the uppermost aquifer	grain size analysis, Atterburg limit
DB3 QM5A	Greenish grey to whitish grey stiff clay with massive calcareous nodule zones	29-34'	above the uppermost aquifer	grain size analysis, Atterburg limit
MW1 ST17	Sandy clay with calcareous nodules	33.5-38.5'	uppermost aquifer	grain size analysis
DB4 QM5A	Clean very fine sand with calcareous grains	33.5-38.5'	uppermost aquifer	grain size analysis
DB2 QM7A	Clay, no further description	38-43'	between the 2 aquifers	grain size analysis, Atterburg limit
MW3 SB2	Clay, no further description	65-66.5'	between the 2 aquifers	grain size analysis, Atterburg limit
MW3 SB3	(Clayey) silty to clean fine to very fine sand	85-94'	lower aquifer	grain size analysis
MW3 SB4	Stiff reddish brown clay with blue-green mottlings, iron oxide pockets and occasional clay pockets or stringers	94-95.5'	below the lower aquifer	grain size analysis, Atterburg limit

Key to abbreviations:

DB - deep boring

MW - monitor well

ST - Stelby tube sampling apparatus

QM - core barrel sampling apparatus

TABLE 4-5  
GEOTECHNICAL SAMPLE ANALYSIS

SAMPLE IDENTIFICATION	ATTERBERG LIMIT		UNITED SOIL CLASS.	GRAIN SIZE ANALYSIS								
	PLASTIC LIMIT	LIQUID LIMIT		PERCENT (%) PASSING SIEVE NOS:								
				1" 3/4"	1/2"	3/8"	#4	#10	#40	#60	#200	
DB4 CM2B	20	50	CH					100	99.5	98.3	98.1	95.9
MW1 ST11	18	30	CL	100	99.4	99.4	98.5	96.8	95.3	95.1	90.8	
DB3 CM5A	16	33	CL					100	98.8	96	95.6	71.9
MW1 ST17				95.9	95	94.1	93.1	85	76.3	70.3	69.3	42.6
DB4 CM6A								100	99.9	99.7	99.3	29.6
DB2 CM7A	23	57	CH			100	99.6	97.6	96.2	96		91.7
MW3 SB2	20	48	CL					100	99.7	98.7	98.5	98.1
MW3 SB3								100	99.8	99.8	48.8	
MW3 SB4	27	59	CH			100	99.4	99.4		96.2		

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Key to Abbreviations:

DB - deep boring  
MW - monitor well  
ST - Shelby tube sampling apparatus  
CM - core barrel sampling apparatus

samples show similar plastic limits (23 and 20) when samples exhibit plastic behavior and liquid limits (57 and 48) when samples exhibit liquid behavior. Both samples are composed of greater than 90% silt and clay-sized material.

The sample from the intermediate water-bearing sand, at 85 to 94 feet, is composed of 52% fine sand and 48% silt and clay-sized material.

The last sample was obtained from the clay immediately underlying this water-bearing zone at a depth of 94 to 95.5 feet. This zone is dominated by silt and clay-sized material (96%). This sample showed a plastic limit of 27, which is the highest value of any sample obtained from this site indicating that this sample must contain a greater amount of liquid than other samples tested in order to exhibit plastic behavior. The liquid limit of 59 for this sample, which is also greater than that exhibited by other samples, indicates a relatively high amount of fluid must be present for the samples to exhibit liquid behavior.

The lithologies that were analyzed represent typical lithologies as described on the boring logs (Appendix B-2).

#### 4.6 SUMMARY

Review of data collected from the deep soil borings and monitor well installation program leads to the following conclusions:

- Five deep soil borings were drilled to depths ranging from 38 to 44 feet. Of the five deep boreholes, three were converted into shallow groundwater monitor wells.
- Three other shallow monitor wells were drilled and installed without first being converted from deep borings. Total depths ranged from 43 to 44 feet. One additional monitor well was completed in the intermediate water-bearing zone, total depth of 99 feet.
- Sixty-two deep soil borehole samples, including deep subsurface soil samples from monitor wells, were analyzed for PCBs; 29% tested positive. Values ranged from less than 1 ppm to 350 ppm.

- Subsurface soil samples in the deep borings contaminated with relatively high values of PCBs are limited to the uppermost 1 foot.
- A total of 11 soil samples from deep subsurface boreholes and monitor wells were analyzed for TCE; all samples tested positive, with values ranging from less than 1 ppm to 390 ppm. A sand sample from MW-4, from the uppermost water-bearing sand, showed a reported value of 2000 ppm.
- POP analysis indicates a relatively high amount of TCE present at the 18 to 23 foot depth clay in monitor well MW-2, which is above the uppermost water-bearing zone. A soil sample from monitor well MW-3 at a depth of 54 to 55.5 feet shows 12 ppm TCE.
- The site-specific lithology and grain size analysis shows that the horizon above the uppermost water-bearing zone is predominantly silt and clay-sized material. The sand content in the uppermost water-bearing zone increases from west to east.
- The horizon separating the shallow and intermediate water-bearing zones is primarily composed of silt and clay-sized material.
- The intermediate water-bearing sand is composed of about 50% fine sand and 50% silt/clay-sized material. The unit directly underlying the intermediate water-bearing sand is predominantly silt and clay-sized material.

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SECTION 5  
MONITOR WELL TESTING, SAMPLING, AND ANALYSIS

This chapter presents procedures, data and results from the hydraulic and chemical testing of monitor wells installed in the uppermost and intermediate water-bearing zones. Also included in this section is an analysis of water level and groundwater quality data to define the groundwater regime and groundwater contamination plume.

5.1 WATER LEVEL MEASUREMENTS

Four sets of water level measurements were performed on all seven wells at the ITS site. Water level measurements define the site-potentiometric surface and define the direction and hydraulic gradient of groundwater flow at the site.

5.1.1 Procedures of Computing Water Level Elevations

Water level elevations were computed as follows:

- Depth to water from the top of the casing was determined using a "popper" tape, which makes a sharp sound as the popper hits the water surface.
- This depth was then subtracted from the surveyed top of casing elevation to obtain elevation of water level in each well.
- Tape was rinsed with de-ionized water, acetone and rinsed again with de-ionized water in between each measurement. Water and acetone were later drummed for appropriate disposal.

5.1.2 Results and Data Analysis

The observed depth from top of casing of each well, surveyed top of casing elevation, distance to water levels and elevation of groundwater above mean sea level (MSL) for all wells are summarized in Table 5-1 and details are given in Appendix E-1. The water level measurements and hydraulic gradients are summarized in Table 5-1. The water levels for the shallow water-bearing

TABLE 5-1

SUMMARY LISTING OF WATER LEVEL MEASUREMENTS\*  
AND HYDRAULIC GRADIENTS

<u>Date of Measurement</u>	<u>MW-1</u>	<u>MW-2</u>	<u>MW-3**</u>	<u>MW-4</u>	<u>MW-5</u>	<u>MW-6</u>	<u>MW-7</u>	<u>Hydraulic Gradient</u>
2-5-87	-	42.54	21.53	42.50	42.95	42.97	43.17	-
2-16-87	42.26	42.51	22.26	42.26	42.81	42.97	43.06	0.0036
3-3-87	42.87	43.31	23.46	43.03	43.63	43.56	43.92	0.0035
3-22-87	42.59	42.96	47.61	42.61	43.70	43.28	43.36	0.0030
7-13-87	42.70	43.23	22.19	43.00	43.57	43.56	43.75	0.0035

\* See Appendix E-1 for data pertinent to water level measurements, such as top of casing elevation and distance to water level.

\*\* MW-3 was completed in intermediate water-bearing sand; all others were completed in the uppermost water-bearing sand.

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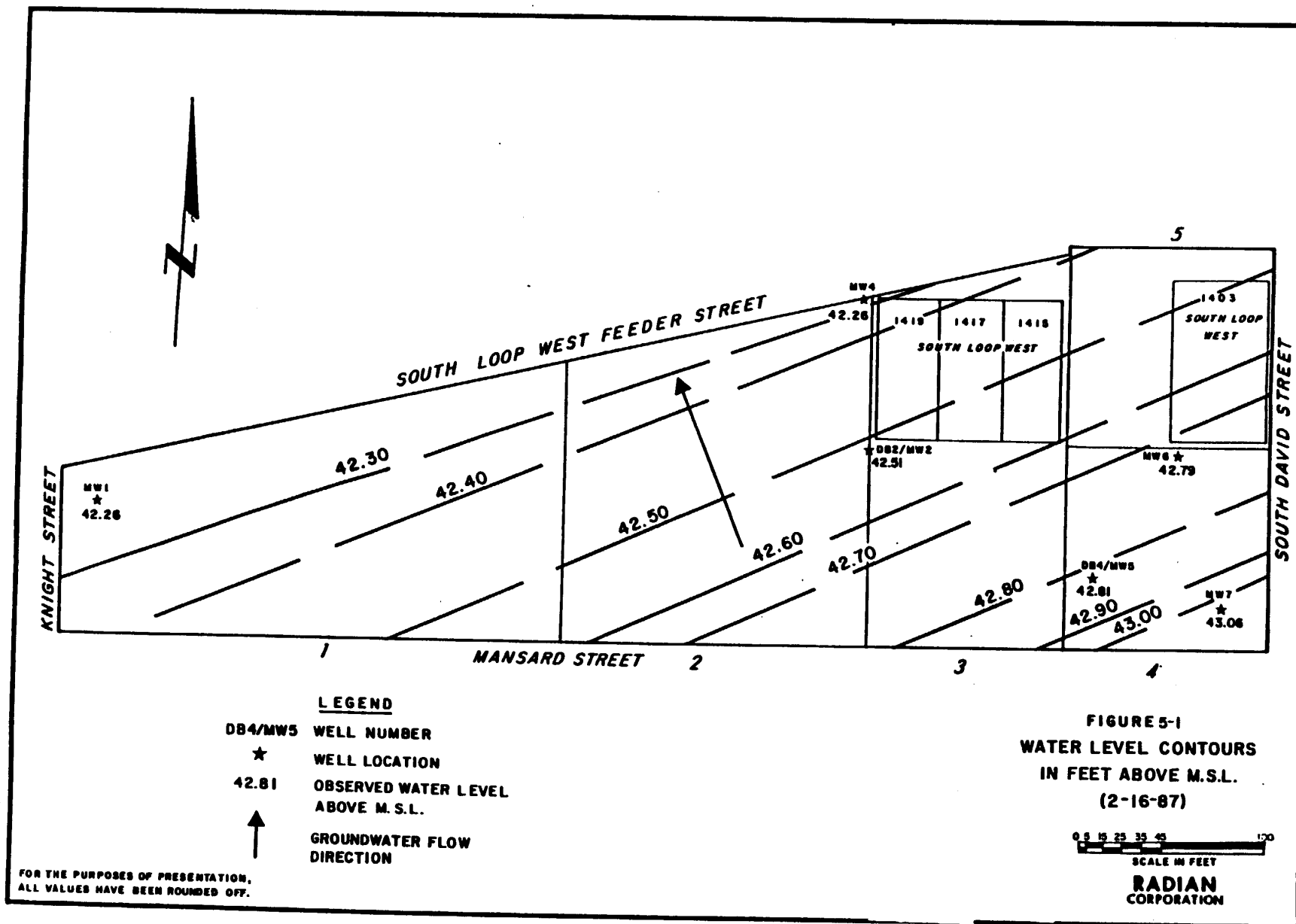


presented in Figures 5-1, 5-2, 5-3, and 5-4; each figure represents one set of measurements. Data from February 5, 1987 has not been plotted because of missing data from monitor well MW-1. (Note that MW-3 is in the intermediate water-bearing zone and, thus, is not included in figures illustrating the hydraulic gradient.) As is evident from the five sets of water level measurements, the groundwater elevations and flow directions have remained consistent during this period. The predominant flow direction is north-northwest. The hydraulic gradient also remains consistent, ranging from 0.0030 feet/foot to 0.0036 feet/foot (Table 5-1). The hydraulic gradient for the Chicot aquifer in the vicinity of the site averages 0.0046 feet/foot.

The static water level of MW-3 averages about 25.68 feet below ground level. This is a much lower static water level than that of the shallow wells, which are typically 3 to 4 feet below ground level. Thus, the existing head differences will favor a downward movement of water from the upper aquifer to the lower (intermediate) aquifer. In a regional sense, the significant difference in the potentiometric level indicates little or no hydraulic connection between the two zones; a pump-test or long-term water level observations would provide a definitive answer at the ITS site itself.

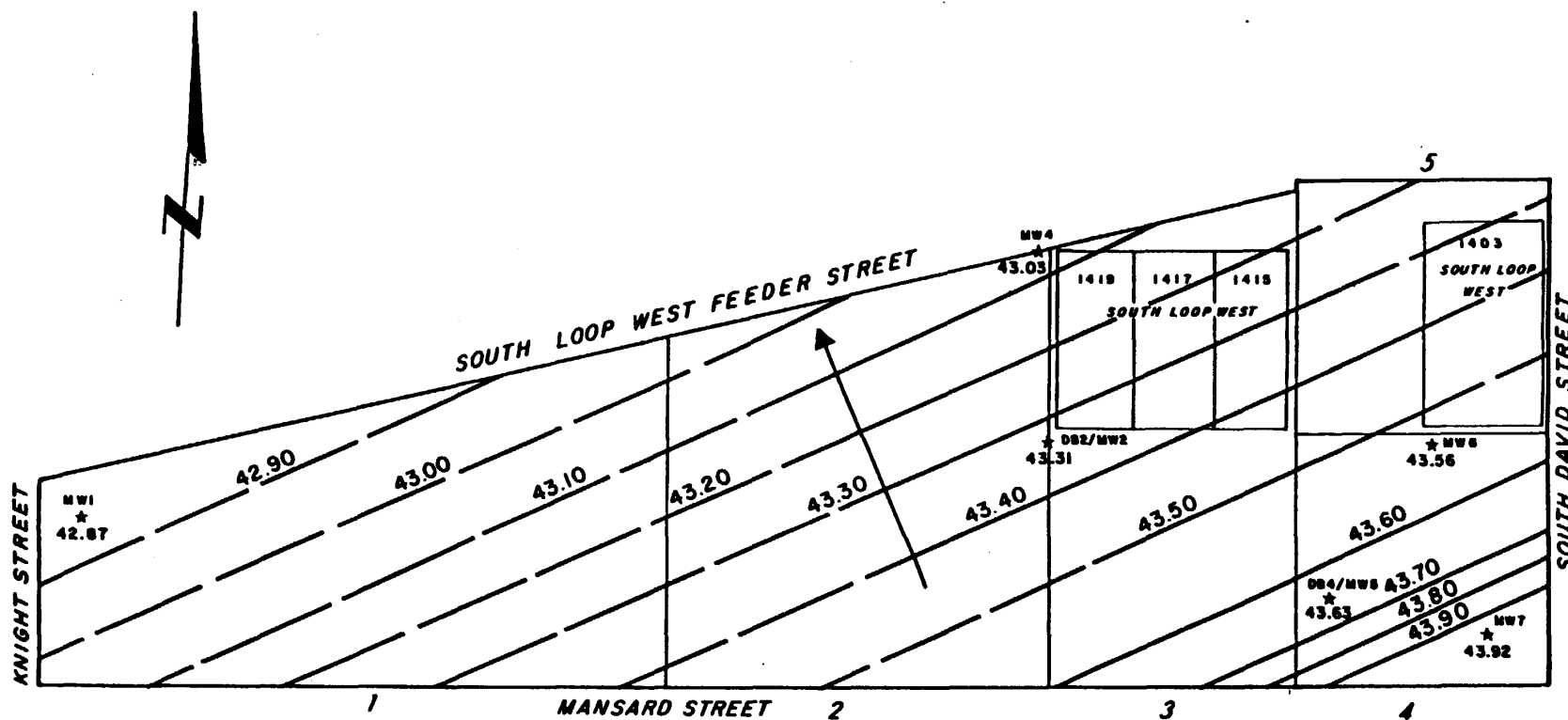
## 5.2 FALLING HEAD TESTS OF MONITOR WELLS

To assess the ability of the water-bearing sands to transmit fluids, falling head tests were conducted after well development to measure hydraulic conductivity (K) and transmissivity (T) following well completion and well development procedures. The Bouwer and Rice (1976) method of determining hydraulic conductivity in unconfined aquifers was used here. A comparison of methods with Cooper, et al. (1967) in confined aquifers shows the two methods result in similar results, as stated by Bouwer and Rice (1976).



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S-5



**LEGEND**

DB4/MW5 WELL NUMBER

★ WELL LOCATION

43.63 OBSERVED WATER LEVEL ABOVE M.S.L.

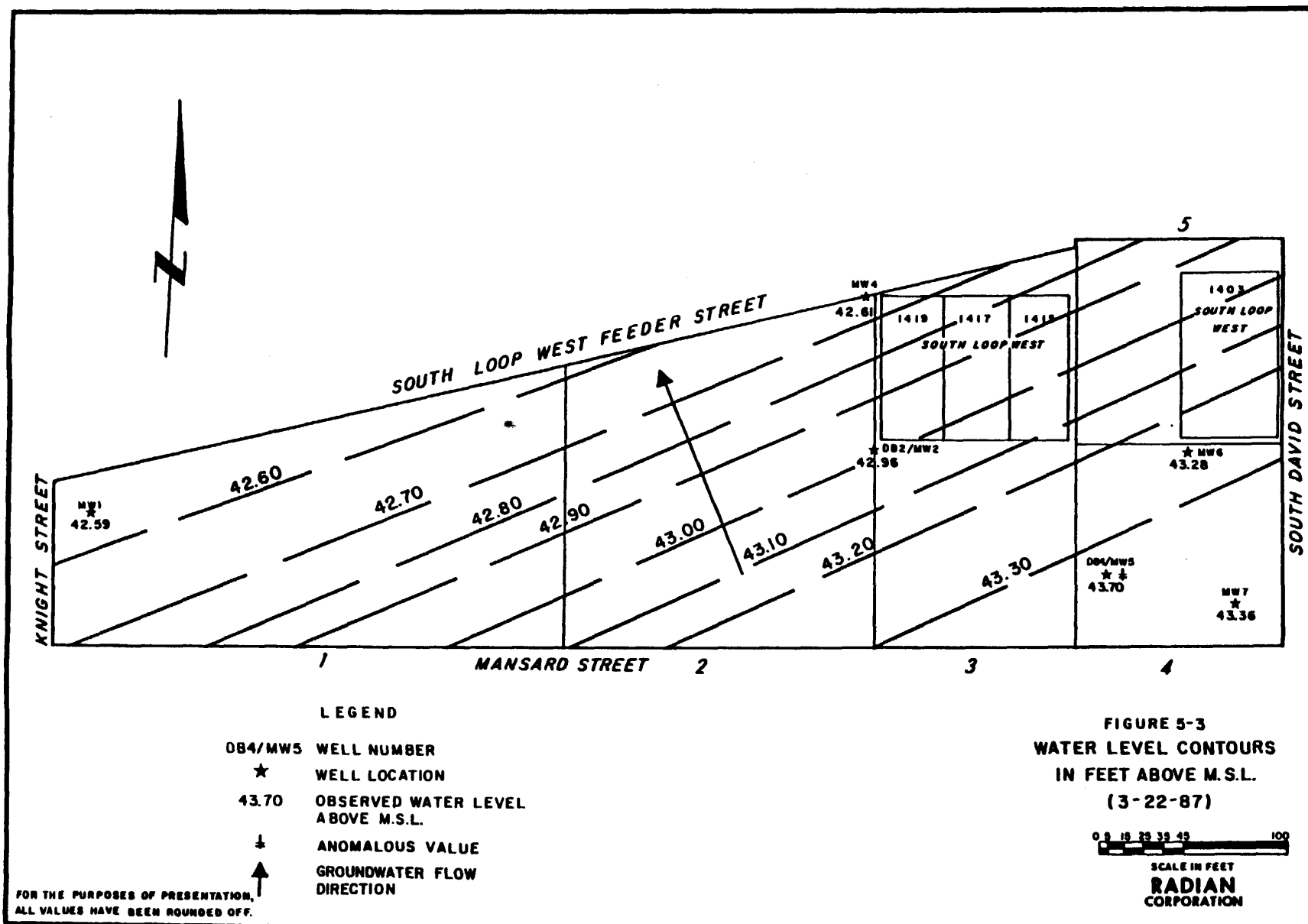
↑ GROUNDWATER FLOW DIRECTION

FOR THE PURPOSES OF PRESENTATION,  
ALL VALUES HAVE BEEN ROUNDED OFF.

**FIGURE 5-2**  
**WATER LEVEL CONTOURS**  
**IN FEET ABOVE M.S.L.**  
**(3-3-87)**

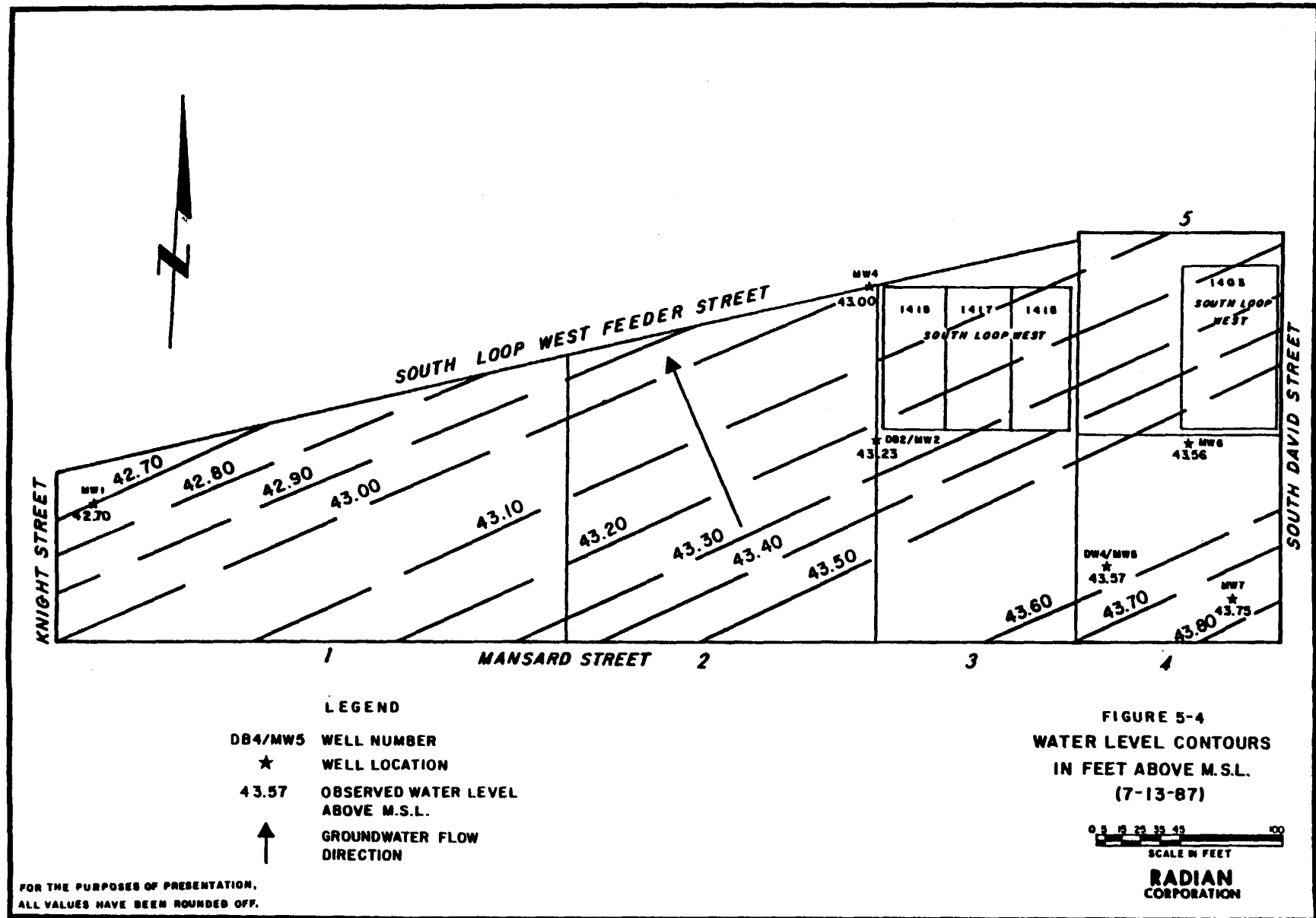
0 5 15 25 35 45 100  
SCALE IN FEET  
**RADIAN**  
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### 5.2.1 Test Location

Falling head tests were performed on each of the six shallow wells and the one intermediate well at the ITS site. However, the values for the intermediate well are of questionable reliability due to siltation problems in MW-3 as discussed in Appendix E-3. The siltation does not extend into the screened-in portion of the wells completed in the uppermost water-bearing zone.

### 5.2.2 Test Procedures

The following procedures were used:

- Static water level was measured with "popper" tape and recorded.
- City water\* (from a spigot at the 1419 South Loop West address) was pumped into each well until the casing was filled to the top.
- With the "popper" tape, water level was measured, every five minutes for the first 30 minutes and then every 15 minutes until completion of the test, with the maximum duration of the test being five hours.
- Data was recorded in a field log book.

### 5.2.3 Computation Procedures

The hydraulic conductivity (K) and transmissivity (T) estimates were made using equations developed by Bouwer and Rice (1976). The observed water levels during the test and the computations are given in Appendix E-2.

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\* See Section 2.4.3 City of Houston Water Quality.

#### 5.2.4 Results and Data Analysis

Hydraulic conductivity (K) data for the uppermost water-bearing zone ranges from 0.6 to 2.0 feet/day (see Table 5-2). The highest hydraulic conductivity, 2.03 feet/day, is located in the aquifer material present in DB-2/MW-2. The next lower value, 1.64 feet/day, is reported at MW-6, then 1.45 feet/day at MW-7, 0.88 feet/day at MW-4, 0.82 feet/day at MW-5, and 0.63 feet/day at MW-1 (see Figure 5-5). The hydraulic conductivity values differ because of variations in porosity, grain size, grain shape, sorting and packing. However, the variation of hydraulic conductivity values observed in the shallow aquifer is typical of poorly sorted silty sands. The hydraulic conductivity for the intermediate zone has been computed to be 0.029 feet/day at MW-3.

Transmissivity, a arithmetic product of hydraulic conductivity and aquifer thickness, represents the quantity of water which passes through a unit width of the aquifer under a unit hydraulic gradient. It follows the same pattern as hydraulic conductivity, since transmissivity is a function of hydraulic conductivity (see Figure 5-6).

#### 5.3 MONITOR WELL WATER SAMPLING

The purpose of the monitor well sampling program was to identify the nature, extent and magnitude of contamination in the shallow (uppermost) and intermediate water-bearing zones. Limited data collected in the past by other regulatory agencies indicate TCE contamination of the shallow groundwater. Significant PCB contamination of surface soils was also observed at the site. Hence, this testing program was essentially directed at testing of water samples for TCE. However, in order to obtain a comprehensive picture of the contamination, a few of the groundwater samples were also analyzed for VPOP.

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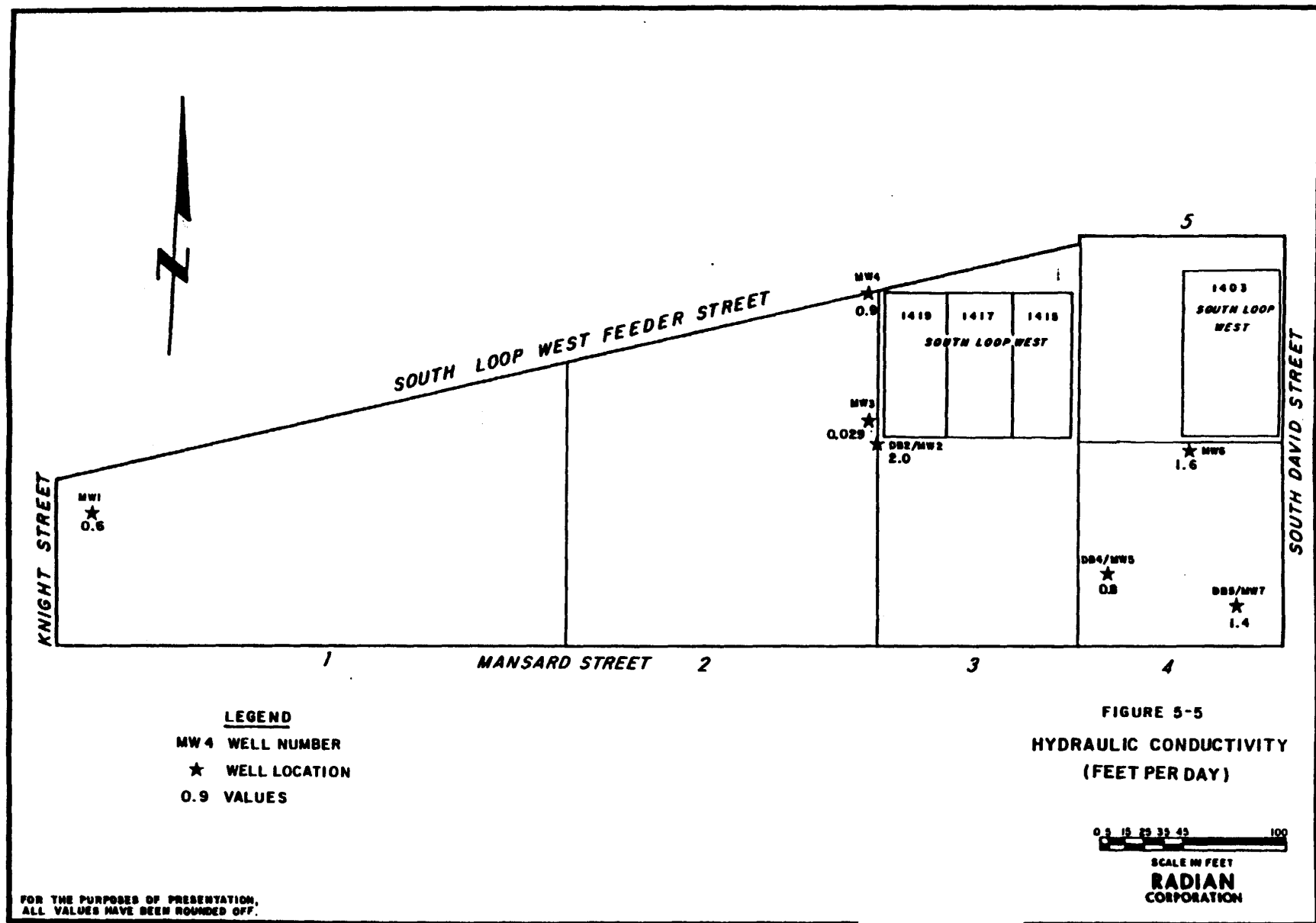
TABLE 5-2  
HYDRAULIC CONDUCTIVITY AND TRANSMISSIVITY DATA FOR  
UPPER AND LOWER AQUIFER SAND SAMPLES

<u>Well Identification</u>	<u>Aquifer Tested</u>	<u>Hydraulic Conductivity(K)</u>	<u>Thickness(ft)</u>	<u>Transmissivity(T)</u>
MW1	shallow	0.632 ft/day	4.8	3.03 ft <sup>2</sup> /day
MW2	shallow	2.030 ft/day	5	10.15 ft <sup>2</sup> /day
MW3	intermediate	0.029 ft/day	9	0.261 ft <sup>2</sup> /day
MW4	shallow	0.878 ft/day	5	4.39 ft <sup>2</sup> /day
MW5	shallow	0.821 ft/day	5	4.11 ft <sup>2</sup> /day
MW6	shallow	1.64 ft/day	5	8.20 ft <sup>2</sup> /day
MW7	shallow	1.45 ft/day	4	5.80 ft <sup>2</sup> /day

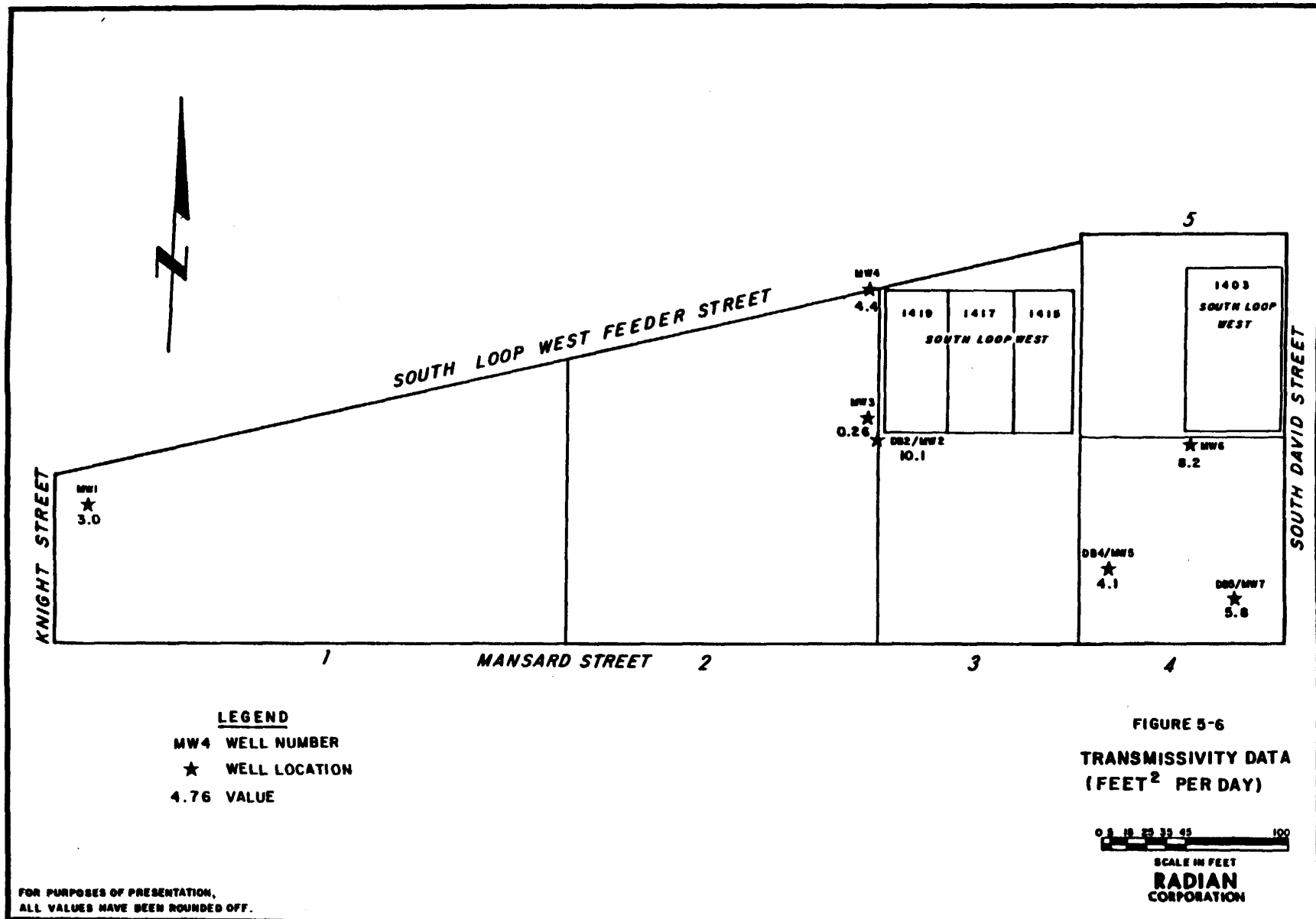
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Groundwater samples were collected from monitor wells penetrating the shallow (or uppermost) water-bearing zone (MW-1, MW-2, MW-4, MW-5, MW-6, and MW-7) and the intermediate water-bearing sand (MW-3 only).

#### 5.3.1 Sample Type, Location and Number

Two rounds of water sampling and analyses were planned in this RI. The first round was completed on February 17, 1987. The second round of sampling was completed March 22, 1987. However, because of sedimentation problems as described in Appendix E-3, MW-3 could not be sampled properly in the second round. Subsequently, a third water sample was collected from this well. The first round of samples was collected prior to hydraulic testing of wells.

A water well at the warehouse in Area 5 (see Figure 1-2) is currently being used as a water supply. A water sample was collected from this well and analyzed for TCE. This well was reputed to be 300 feet deep by the current operator of the site. No completion information is available.

Field (equipment) blanks were collected during field work for QA/QC purposes.

#### 5.3.2 Sampling Method and Procedures

The following procedures were used to obtain and analyze water samples from monitor wells:

- Depth to water level from top of casing was measured, using a "popper" measuring tape. Then distance to water surface from ground elevation was computed using a survey of the ground surface and the top of casing elevations.
- Height of the column of water was computed and volume of water within the casing was calculated.

- A stainless steel bailer was lowered to the bottom of the water column and brought up. The contents of the bailer were poured into a bucket, measured and then emptied into a 55-gallon drum. The bailing was continued until three times the computed volume of water within the casing was evacuated from the well.
- Drums of bailed water were appropriately marked, sealed, and stored within the fenced area.
- After three casing volumes of water were evacuated, the bailer was filled with well water again and brought to the surface.
- As the bailer was emptied, a glass septum 40 ml sample bottle was held in the water stream and filled so there were no bubbles in the vial. Other sample bottles were also filled. The bottles were labeled, a chain of custody form was filled out, and the samples were stored in a cooler.
- The bailer was taken apart, washed, rinsed, sprayed with acetone and rinsed in de-ionized water between sampling each well. The rope used to lower the bailer into the well was also cleaned in the same manner.
- Decontamination water was contained for disposal at a treatment, storage, or disposal facility in compliance with EPA's off-site disposal policy.
- Field (equipment) blanks were collected following the above procedures. The field blanks aid in assessing QA/QC.

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### 5.3.3 Analytical Methods and Procedures

All 15 water samples (2 rounds of all 6 shallow wells and three rounds of intermediate well MW-3) were analyzed for TCE. Four additional samples were chosen for VPOP analysis during the second round of sampling, based on relatively high TCE content observed during the first round of sampling.

Appendix C-4 states the analytical methods, preservation, shipping, and handling requirements for the groundwater samples.

#### 5.3.4 Results and Data Analysis

Table 5-3 summarizes TCE data from the two rounds of sampling the shallow (uppermost) water-bearing zone and three rounds of sampling the intermediate water-bearing zone. Concentrations for the first round sampling from the uppermost water-bearing sand are shown on Figure 5-7. Concentrations for the second round of sampling are shown on Figure 5-8.

Even though individual values vary between the first and second rounds for a given well, the overall ranking of wells in terms of concentration of TCE remain the same in both rounds. In the shallow aquifer, highest concentrations (for both rounds) have been observed in MW-2 (430 ppm and 500 ppm for rounds 1 and 2, respectively) followed by MW-4 (250 ppm/400 ppm), then MW-5 (190 ppm/300 ppm). The other 3 wells have considerably lower values for TCE: MW-7 (46 ppm/72 ppm), MW-6 (25 ppm/26 ppm) and lastly, MW-1 (0.003 ppm/0.007 ppm). All six wells show consistently higher values in the second round of sampling when compared to the first round.

MW-3, completed in the lower aquifer (84-94 feet), was sampled and analyzed three times. Values for Rounds 1, 2, and 3 respectively were 26 ppm, 2.1 ppm, and 0.12 ppm TCE; however, the last two values are of questionable accuracy due to problems in the well (Appendix E-3). Data from this well, including water samples, soil samples, hydraulic conductivity, transmissivity and hydraulic gradient information will be replaced with information from another intermediate well to be drilled in Phase II investigations. MW-3 will be plugged and abandoned as part of Phase II work.

VPOP analyses identified TCE to be the contaminant present in the groundwater wells. Table 5-4 lists TCE values as analyzed by VPOP methods. The comparative ranking remains the same between the wells, with MW-2 containing the highest amount of TCE, 320 ppm, MW-4 containing 310 ppm, and MW-5

TABLE 5-3  
TRICHLOROETHENE (TCE) DATA

Monitor Well Water Samples

<u>Sample Identification *</u>	<u>Depth</u>	<u>Round 1 Results(ppm)</u>	<u>Sample Identification</u>	<u>Round 2 Results(ppm)</u>	<u>Sample Identification</u>	<u>Round 3 Results(ppm)</u>
MW-1	Uppermost Aquifer	0.0035	MW-1A	0.0007		
MW-2	Uppermost Aquifer	430	MW-2A	500		
MW-3	Intermediate Aquifer	26	MW-3A	2.1	MW-3B	0.120
MW-4	Uppermost Aquifer	250	MW-4A	400		
MW-5	Uppermost Aquifer	190	MW-5A	300		
MW-6	Uppermost Aquifer	25	MW-6A	26		
MW-7	Uppermost Aquifer	46	MW-7A	72		

Water Well Water Samples

WW-1	300 feet	0.003
------	----------	-------

\* A total of up to 3 rounds of water samples were collected for TCE analysis from some of the wells; each round of samples is labeled uniquely, i.e., "MW-1" sample identification refers to the first round of sampling; "MW-2A" sample identification refers to the second round of sampling and "MW-3B" refers to the third round of sampling.

TABLE 5-4

## VOLATILE PRIORITY ORGANIC POLLUTANTS (VPOP) DATA

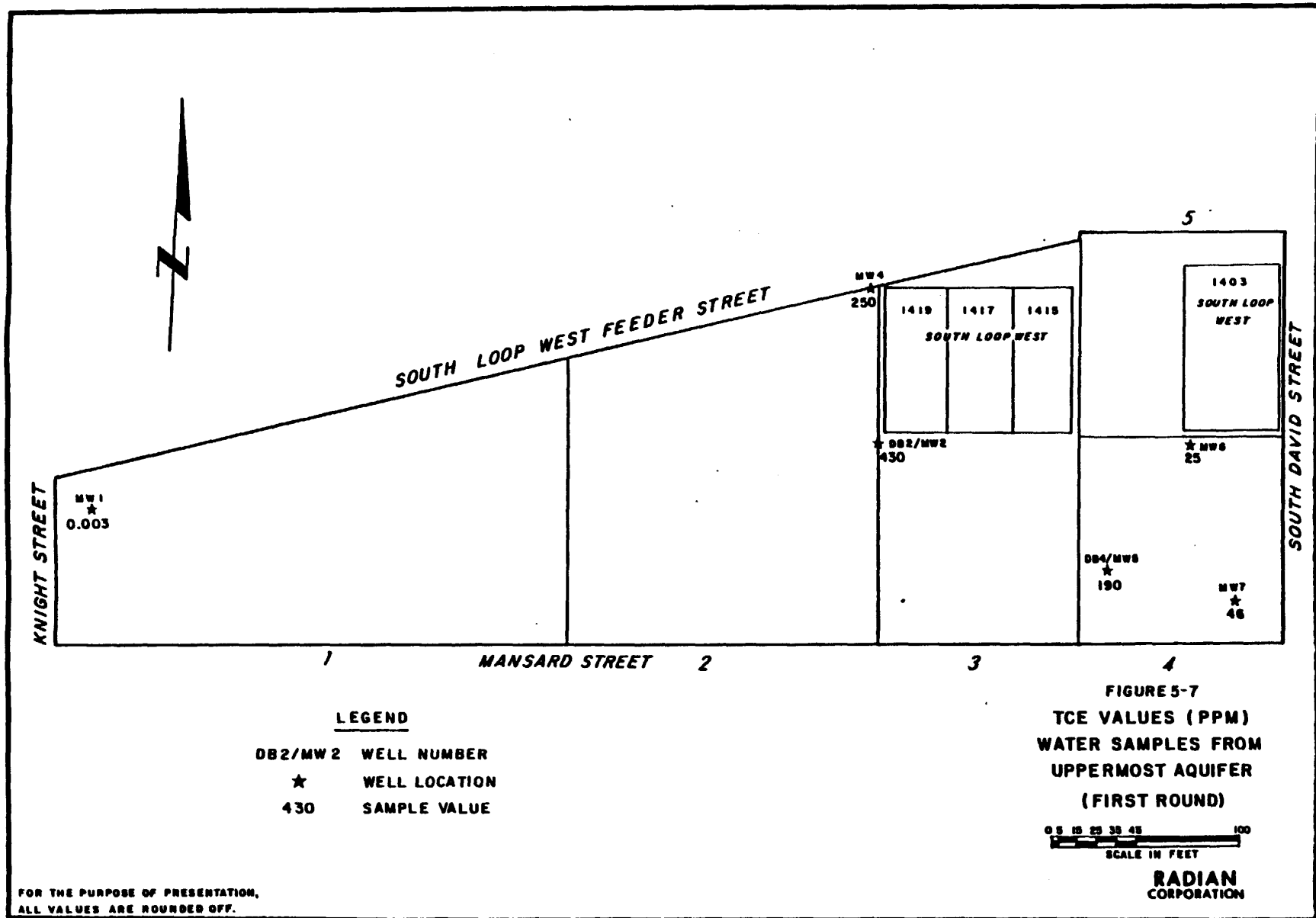
Monitor Well Water Samples

<u>Sample Identification*</u>	<u>Compound</u>	<u>Value(ppm)</u>
MW-2B	TCE	320
MW-3B	TCE	1.5
MW-4B	TCE	310
MW-5B	TCE	190

\* These VPOP samples were collected at the same time as the second round of water samples were collected for TCE analysis and labeled "MW-2A", "MW-2B", etc. to distinguish samples collected for VPOP analysis from those collected for TCE analysis.

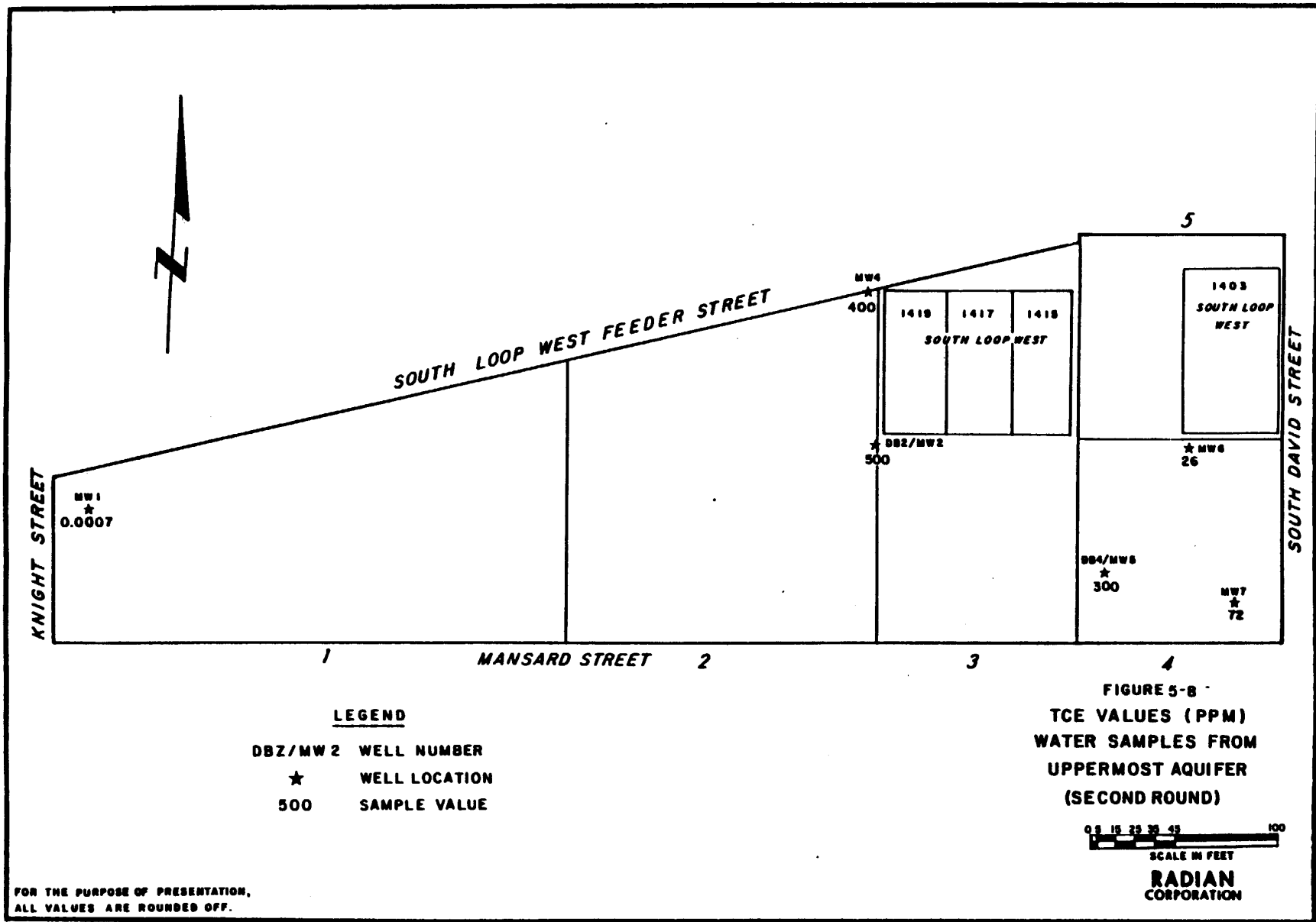
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5L6000





9L6000



reporting 190 ppm. VPOP analysis of MW-3 water yielded a value of 1.5 ppm, close to the value of the second round of TCE data (2.1 ppm). Both water samples were collected from the well at the same time during the second round of sampling. No other compounds were detected. The differences in the TCE values from the VPOP analyses and the TCE analyses can be explained by the differences in sampling methods and the non-homogenous distribution of the TCE in the groundwater.

The water sample (WW-1) collected from the former Con-Equipment building water well, contains 0.003 ppm TCE. Interpretation of this one data point is hindered by the lack of complete information, an unknown total depth and lack of additional samples to verify this one sample.

#### 5.3.5 Review of Groundwater Flow and Quality Data

The highest TCE concentrations have been observed at MW-2. However, since upgradient wells show significant concentrations of TCE, a review of the groundwater gradient and the observation of TCE concentrations do not indicate a plume which may have originated at MW-2. While no obvious reason has been identified, the distribution and concentrations of TCE contamination could be an indication of a reversal of a groundwater gradient over time. This data also suggest the presence of presence of several scattered sources of TCE contamination at or close to the soil surface which have vertically migrated down to the uppermost water-bearing zone.

The high TCE concentrations at MW-2 may possibly be explained by the previous existence of a nearby water well, at which contamination through the actions of surface water or tampering may have migrated along the casing to the water-bearing zone. During the RI, this water well could not be located. Because no information on the construction of the well or its closure exists, this well may be provided a pathway for vertical migration of TCE to the water-bearing zone.

Further investigation of groundwater (both the uppermost and intermediate water-bearing sands) is to be completed in Phase II work.

#### 5.4 CONCLUSIONS

A review of water level measurements, falling head tests and chemical data leads to the following conclusions:

- Four sets of complete and one set of incomplete static water level measurements were gathered from the seven wells at the ITS site; a north-northwesterly potentiometric surface gradient was established for the uppermost water-bearing sand. The observed gradients range from 0.0030 feet/foot to 0.0036 feet/foot.
- Falling head (slug) tests were used to establish the hydraulic conductivity (K) and transmissivity (T) at each well. Hydraulic conductivities were 2.03 (MW-2), 1.64 (MW-6), 1.45 (MW-7), 0.88 (MW-4), 0.82 (MW-5), 0.63 (MW-1), and 0.029 (MW-3) feet<sup>2</sup>/day. Transmissivities are 10.12 (MW-2), 8.15 (MW-6), 5.76 (MW-7), 4.38 (MW-4), 4.13 (MW-5), 3.03 (MW-1), and 0.252 feet<sup>2</sup>/day.
- Two rounds of groundwater samples were collected from the six monitoring wells (completed in the uppermost water-bearing aquifer) and analyzed for TCE. Highest concentrations of TCE were centered around MW-2, followed by MW-4, then MW-5, MW-6, and MW-7. MW-1 showed the least amount of contamination. Water samples from these wells ranked in the same order for both rounds.
- Three rounds of groundwater samples were collected and analyzed for TCE from MW-3 which is completed in the intermediate aquifer. Values decreased each of the three rounds in MW-3; these samples are suspect because of siltation problems and possible dilution problems during the falling head (slug) test.
- No organic compounds other than TCE were reported in the VPOP analysis.

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SECTION 6  
SURFACE WATER AND SEDIMENT INVESTIGATION

This chapter presents a discussion of field investigations (sampling, analysis, and review of data) carried out at the ITS site for water flowing in drainage ditches adjacent to the site, water which ponds at the site after a storm and the sediments in the adjacent ditches. Stormwater that has drained off-site and into shallow ditches bordering two sides of the ITS site or collected in the depressions on the site are discussed in Section 6.1 Stormwater Samples. Sediments in the ditches are discussed in Section 6.2 Sediments. Conclusions drawn from surface water and sediment data are given in Section 6.3 Conclusions.

6.1 STORMWATER SAMPLES

Shallow ditches bordering the ITS site (Knight and Mansard Streets) collect stormwater run-off from the site, the road and areas further upstream of the ITS site. During storm events and subsequent run-off, surficial soils are eroded, held in suspension and carried along with the run-off. Subsequently, contaminated soils can settle out of the run-off, or the contaminants can leach from the soils into the water. The site drainage system is further described in Section 2.5 of this report.

6.1.1 Sample Type, Location and Number

The National Weather Bureau reported 0.16 inches of rain on February 19, 1987, between noon and midnight and 0.33 inches of rain on February 20, 1987, between 4:00 am and 10:00 am. Both measurements are from an official National Weather Bureau location at the corner of Franklin and Fannin Streets in downtown Houston approximately 3.5 miles north of the ITS site (personal communications, 1987).

Stormwater samples were collected from seven locations as shown in Figure 6-1 on February 20, 1987. Two of the seven samples (SW-2 and SW-7) are from an off-site location both of which are 50 feet off the eastern edge of the map depicted on Figure 6-1. The purpose of acquiring these samples was to determine if run-off has transported PCBs off-site. Two of the samples, SW-1 and SW-6, are from ponded water within the site. Since PCBs are associated with sediment and thus are susceptible to off-site transport via run-off containing sediments, all stormwater samples were analyzed for PCBs. Two of the samples were also selected for POP analyses.

#### 6.1.2 Sampling Method and Procedures

Collections procedures were as follows:

- A 1 liter glass jar with teflon-lined cap and a 40 ml glass septum bottle were lowered into the ditch. The samples were collected near the surface of the ditch water such that surface debris was not collected. Personnel wore rubber boots and gloves during sampling.
- Samples were labeled, stored in a cooler, and transported to the laboratory for analysis. Chain-of-custody procedures were followed.
- Boots and gloves were washed, rinsed, sprayed with acetone and rinsed in de-ionized water between sampling events. The decontamination water was contained for later, appropriate disposal.

#### 6.1.3 Analytical Methods and Procedures

Seven 1-liter samples were analyzed for PCBs, and two 40 ml samples were analyzed for POP.

#### 6.1.4 Results

Except for one sample, no PCBs were detected in the run-off water samples (see Table 6-1), indicating the low potential for contaminant migration off-site via surface water run-off under the present conditions. Locations of the surface water samples are illustrated in Figure 6-1.

TABLE 6-1

POLYCHLORINATED BIPHENYLS (PCBs) DATA

Stormwater Samples

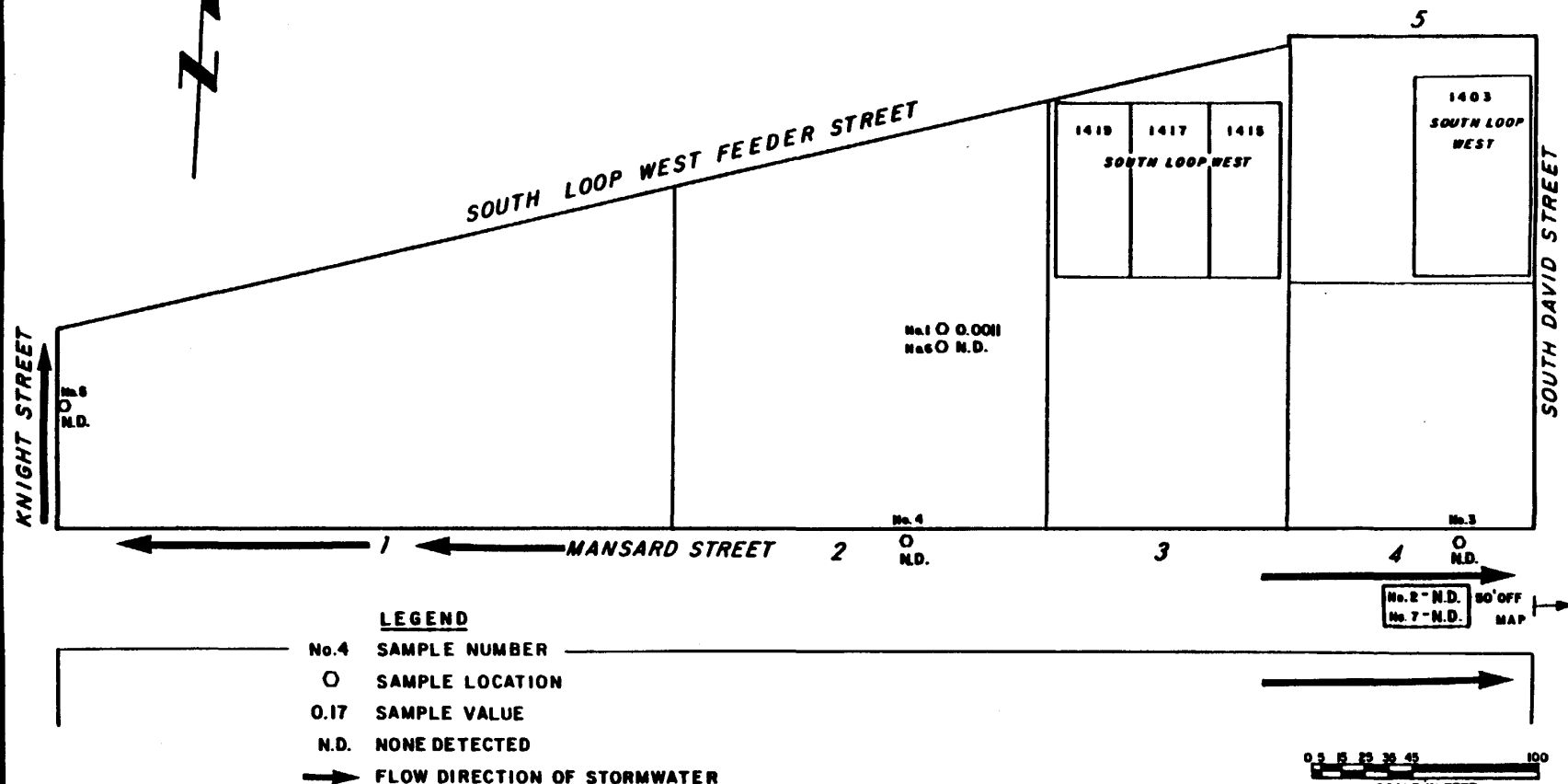
<u>Sample Identification</u>	<u>Value (ppm)</u>
SW-1	0.0011
SW-2	N.D.
SW-3	N.D.
SW-4	N.D.
SW-5	N.D.
SW-6	N.D.
SW-7	N.D.

N.D. - Not Detected

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FIGURE 6-1  
FLOW DIRECTION OF  
STORMWATER AND WATER  
SAMPLE LOCATIONS  
PCBS (PPM)



Sample SW-1, close to a contaminated area, shows the presence of low concentrations of PCBs (0.0011 ppm).

The POP analyses (see Table 6-2) indicate the presence of TCE at 0.0026 ppm and phenol at 0.002 ppm in sample SW-6. This sample was collected on-site, at a location downstream of run-off from the ITS site. This location collects rainfall run-off from the ITS site as well as drainage from other lots in the vicinity of the site.

## 6.2 SEDIMENTS

Prior to this investigation, other regulatory agencies had collected sediment samples from ditches adjacent to the ITS site. These samples contained TCE and PCBs in detectable amounts. This investigation plans to expand the sampling done adjacent to the site and verify any occurrence of off-site transport of contaminated soil.

Contaminated soils are eroded, held in suspension and carried off-site in the run-off water to the shallow drainage ditches along Mansard and Knight Streets, where some of the sediments are deposited at the bottom of the ditch.

### 6.2.1 Sample Type, Location and Number

Sediment samples were collected in the bottoms of drainage ditches along Mansard and Knight Streets. Two samples were taken from the ditch along Knight Street. Three more samples were collected from the ditch along Mansard Street across from the ITS site and one sample was taken from the ditch along South David Street across from the ITS site. Two of the six samples were from off-site areas. Off-site samples were selected to determine if past run-off activities had resulted in wash-off and subsequent deposition of sediments. Figure 6-2 shows locations of the sediment samples.



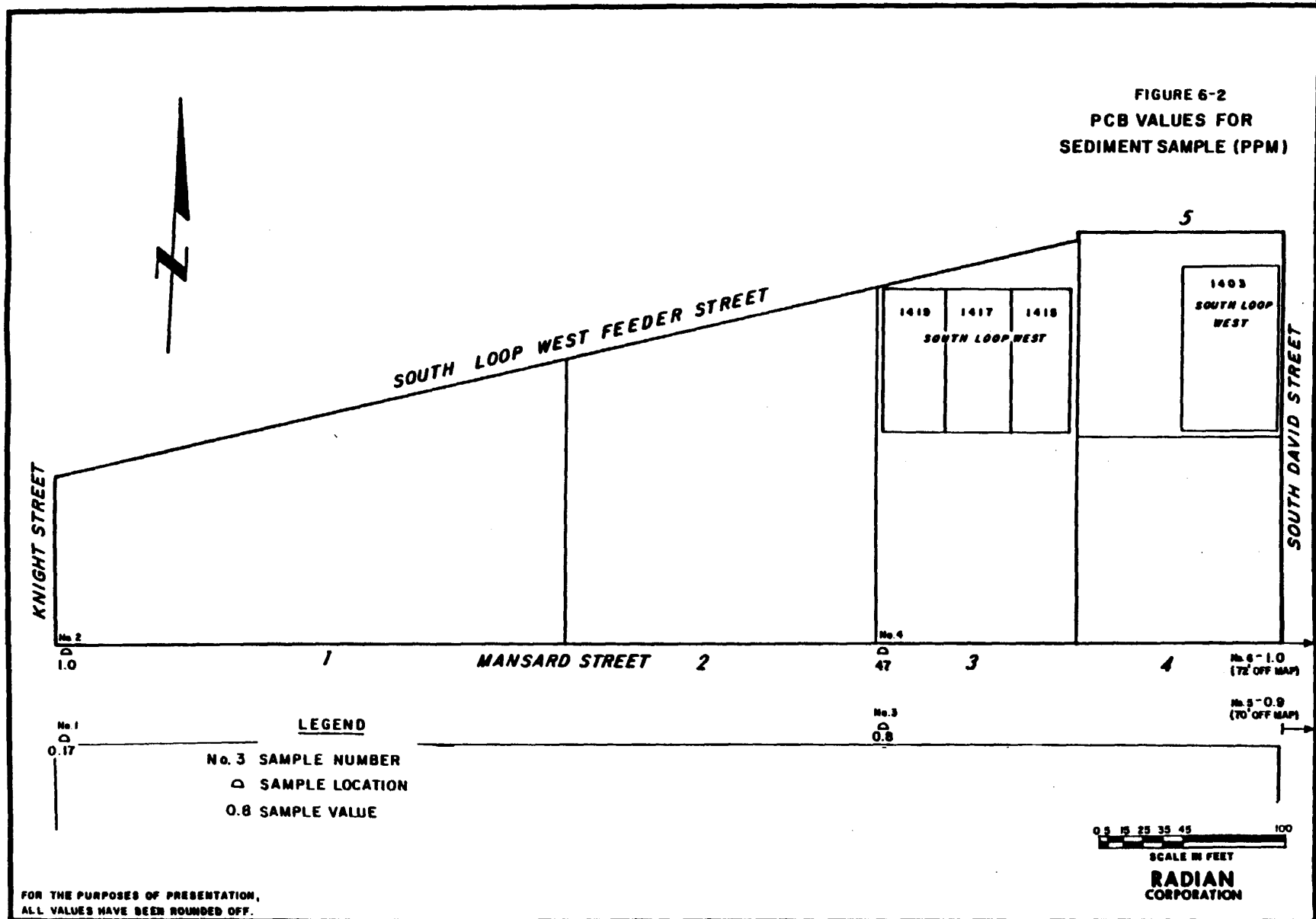
TABLE 6-2  
PRIORITY ORGANIC POLLUTANTS (POP) DATA  
Stormwater Samples

<u>Sample Identification</u>	<u>Compound</u>	<u>Value (ppm)</u>
SW-6	Phenol	0.002
	Trichloroethene	0.0026
SW-7	No compounds detected	

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FIGURE 6-2  
PCB VALUES FOR  
SEDIMENT SAMPLE (PPM)



#### 6.2.2 Sampling Method and Procedures

Collection methods were as follows:

- Vegetation and trash were removed using a clean hand-held rake.
- Chrome-plated steel trowels were used to collect the sediments in the bottom of the ditches.
- Visible and olfactory contamination were noted and the samples were screened for volatiles using an HNu analyzer.
- Trowels were cleaned with acetone and de-ionized water between sampling.
- The samples were transferred to clean glass sample bottles with teflon-lined caps, labeled, stored in a cooler and transported to the laboratory for analysis. Chain-of-custody procedures were followed.

#### 6.2.3 Analytical Methods and Procedures

A total of six sediment samples were collected when the ditches were dry. All samples were analyzed for PCBs, which tend to bind to soil particles. HNu screening was performed, a sample was allowed to sit in a closed bottle for a minimum of 30 seconds, then the HNu "wand" was inserted into the bottle, and a reading was recorded. This procedure did yield positive readings which are indicative of the presence of volatile organics, such as TCE. Because TCE readily volatilizes and, therefore, would likely not be present in surface sediments, none of the sediment samples was analyzed for TCE. Appendix C-4 presents the analytical methods and preservation requirements for surface soil samples.

#### 6.2.4 Results and Data Analysis

PCB data are summarized in Table 6-3, and sample locations are illustrated in Figure 6-2. The data indicate very low PCB values in all but one of the the sediment samples. Five samples contained less than 1.1 ppm, and the other sample contained 47 ppm PCBs. While the elevated PCB value observed at SD-4 may suggest an impact from the ITS site, no sediment background sample was successfully collected due to run-off configurations to

TABLE 6-3

POLYCHLORINATED BIPHENYLS (PCBs) DATA

Sediment Samples

<u>Sample Identification</u>	<u>Value (ppm)</u>
SD-1	0.17
SD-2	0.66
SD-3	0.85
SD-4	47
SD-5	0.083
SD-6	1.11

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SECTION 7  
AIR SAMPLING

Ambient air sampling was conducted to assess the potential release of contaminants from the site to the air.

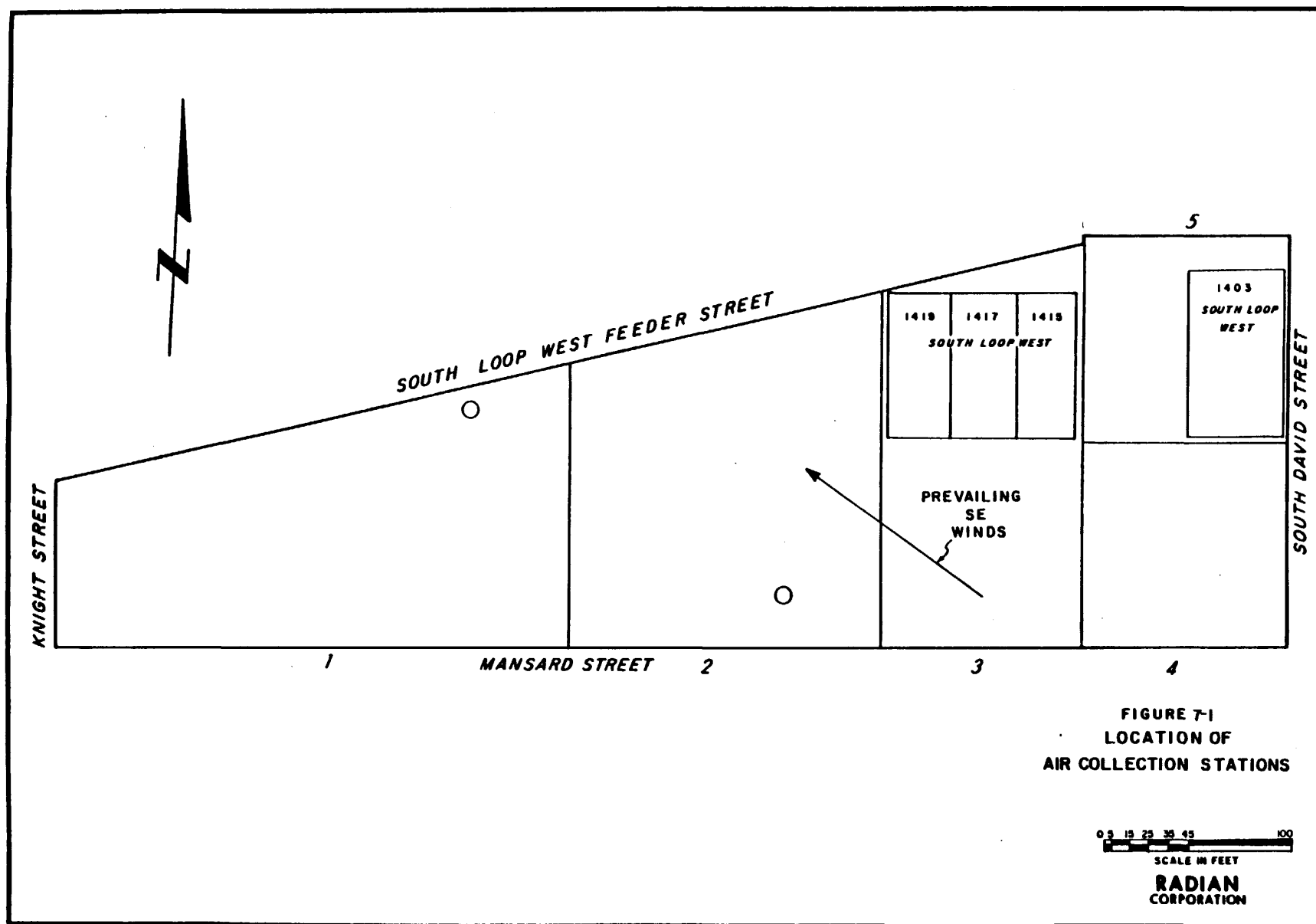
7.1 SAMPLE TYPE, LOCATION AND NUMBER

Hi-Vol samples were collected upwind and downwind of the site for the air sampling activities. Sample locations were selected by visually observing the upwind and downwind directions at the site in order to determine the extent, if any, of the migration of windborne contaminants from the site during different time periods. Figure 7-1 illustrates the upwind and downwind air sampling locations when prevailing winds are from the southeast direction. Sampling locations changed each day, depending on actual conditions at the site.

The primary deviation from the air sampling plan was based on an on-site evaluation. The on-site reassessment of the air monitoring program resulted in the collection of samples prior to the start of field activities to determine a baseline instead of during field activities, as specified by the Sampling Plan. The collection of samples subsequent to field activities was to determine the impact of field activities on air quality.

However, the theft of the generator used to power the two air collection stations shortened two of the sampling events from 8 hours to 2.5 and 3 hours, respectively, for each of the two collection stations. The theft eliminated the second day of air sampling. These problems resulted in the collection of two, instead of four air samples prior to the start of field activities. Another four samples were collected (for an 8 hour sample period) after the completion of field activities. This resulted in six samples all being analyzed for total suspended particulates but only four samples (those with 8 hour collection periods gathered following completion of field activities) analyzed for PCBs. Also, no data was collected in wind speed and wind direction.

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## 7.2 SAMPLING METHOD AND PROCEDURES

Air sampling was conducted as follows:

- A calibrated sampler was mounted four to six feet above-ground in the designated locations both upwind and downwind of the site. The unit was tested and the filter element, weighed prior to the sampling interval, was installed in the sampler.
- Two four-hour sampling periods were conducted at the start of field work on January 13, 1987. The original sampling period of eight hours was cut short by the theft of the generator from the project site. At the end of the field work, four eight-hour sampling periods were conducted on February 16, 17, and 18, 1987.
- The pre-weighed filter was removed from the sampler and replaced with a new filter after the sampling period. The old filter was placed in a plastic bag, labeled, logged and transported to the laboratory for analysis.

The installation of the air sampler was such that it did not disturb the ground surface.

## 7.3 ANALYTICAL PARAMETERS AND PROCEDURES

All samples were analyzed for total particulates. The two filters that collected particulates before the start of field activities were analyzed for PCBs. Also, one blank filter was analyzed for PCBs as a control. Particulates were determined through gravimetric analysis. PCBs were determined by Method 8080 (EPA, 1986). Handling, storage, and preservation procedures are detailed in Appendix C-4.

## 7.4 RESULTS

No PCBs were detected on any of the filters (Table 7-1). The amount of particulates accumulated in the upwind and downwind filters does not provide conclusive evidence of any significant contributions of particulates from the ITS site.

Table 7-1  
PARTICULATES DATA AND  
POLYCHLORINATED BIPHENYLS (PCBs) DATA  
COLLECTED FROM AIR FILTERS

<u>Sample Identification</u>	<u>Wind Direction</u>	<u>Run Date</u>	<u>Run Time</u>	<u>Hours Run</u>	<u>Particulates (Grams)</u>		<u>Total of Parti- culates (grams)</u>	<u>Total Suspended Particulates (ug/m<sup>3</sup>)</u>	<u>PCB Value</u>
Filter 01A	downwind	1-13-87	1030 - 1330	3	2.8833	2.8940	0.0107	43.423017	NA
Filter 02A	upwind	1-13-87	1030 - 1255	2.5	2.8945	2.8982	0.0037	22.019298	NA
Filter Blank							ND	ND	
Filter 0	upwind	2-16-87	1045 - 1830	7.75	2.8262	2.8809	0.0547	78.200658	ND
Filter 1	downwind	2-16-87	1045 - 1830	7.75	2.8993	2.9334	0.0341	45.359929	ND
Filter 2*	upwind	2-17-87	0830 - 1700	7.75	2.8336	2.8745	0.0409	54.40531	ND
Filter 3**	downwind	2-17-87	1015 - 1815	8	2.7759	2.8588	0.0829	123.253829	ND

ND - Not Detected

NA - Not Analyzed

\* Filter 2, an upwind sample, collected on 2-17-87, was the only filter collected on that day.

\*\* Filter 3, collected on 2-18-87, and a downwind sample, was the only filter collected that day.

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Total suspended particulates (TSP) concentrations ranged from 22 to 54 to 78 ug/m<sup>3</sup> upwind of the site and from 43 to 45 to 123 ug/m<sup>3</sup> downwind of the site. In one case, the TSP concentration was actually higher upwind of the site than downwind of the site. Off-site activities, such as vehicles travelling on the unpaved parts of Mansard Street, appear to control the amount of total suspended particulates on at least one day, February 16, 1987.

Table 7-2 shows an hourly average of wind speeds and directions as measured at a monitoring station about 8 1/2 miles east-southeast of the ITS site.

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TABLE 7-2  
HOURLY AVERAGE WIND SPEEDS  
AND WIND DIRECTIONS\*

<u>Date</u>	<u>Hours</u>	<u>Wind Speed (tenths of a mile)</u>	<u>Wind Direction**</u>
1-13-87	1000	0.5	189°
	1100	0.4	175°
	1200	0.4	172°
	1300	0.7	199°
	1400	0.6	191°
2-16-87	1000	0.8	319°
	1100	0.9	317°
	1200	0.8	327°
	1300	0.8	320°
	1400	0.7	332°
	1500	0.7	320°
	1600	0.8	341°
	1700	0.8	344°
	1800	0.9	342°
	1900	0.8	336°
2-17-87	0800	0.8	330°
	0900	0.6	326°
	1000	1.0	324°
	1100	0.9	332°
	1200	1.0	326°
	1300	1.1	325°
	1400	1.0	314°
	1500	1.0	324°
	1600	0.9	330°
	1700	0.9	330°
2-18-87	1000	0.7	320°
	1100	0.7	323°
	1200	0.7	337°
	1300	0.6	332°
	1400	0.6	326°
	1500	0.6	353°
	1600	0.7	031°
	1700	0.7	057°
	1800	0.7	044°
	1900	0.6	050°

\* Wind speed and direction were not measured at the ITS site. These data were measured at a location about 8.5 miles ESE from the ITS site, at the South Loop 610 West and Manchester exit.

\*\* Wind direction measured clockwise from north, with north at 0°, east at 90°, south at 180°, west at 270° and north at 360°.

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## SECTION 8

### REVIEW OF HEALTH AND ENVIRONMENTAL EFFECTS CRITERIA

This chapter presents an assessment of potential public health effects from the contamination found to be present at the site. The discussion in this chapter includes identification of contaminants of concern, discussion of potential receptors, a literature review of toxicological effects of contaminants and a review of pertinent criteria.

#### 8.1 SELECTION OF INDICATOR CHEMICALS

The data on chemicals present at the site are given in Sections 3, 4, and 5. The data includes analyses of surface soil, soils from shallow and deep borings and groundwater from the uppermost and intermediate aquifers. As described in previous sections, the analyses were completed for the following parameters: PCBs, TCE, dioxins, VPOP, and POP. A review of the data shows that there are only two principle chemicals present at the site, PCBs and TCE.

#### 8.2 RECEPTOR AND EXPOSURE PATHWAYS

According to the 1980 Census Data for Houston, a residential population of about 2,061 persons reside within 1 mile of the ITS site. The combined transient populations brought in by the recreational complexes of Astrodome, Astroworld, and Waterworld result in approximately 100,000 people peak daily attendance. The worker populations within 0.5 miles of the site are estimated to be 250 persons. Populations and land use are discussed in more detail in Section 2-1.

Currently, the City of Houston draws water from the Chicot and Evangeline aquifers, with some percentage of water coming from Lake Houston in northeast Harris County. In the vicinity of the ITS site, the depth to the Chicot aquifer is about 200 feet and to the Evangeline is about 270 feet

(Harris County Soil Survey; TDWR, 1980). At the ITS site, the uppermost aquifer is at about a depth of 30 feet and the next lower aquifer is at 90 feet.

There are a number of water wells within a 1-mile radius of the site (see Table 2-1); most appear to be completed in the deeper regional aquifers (Chicot, Evangeline, etc) but a few wells tap the near-surface aquifers. It is not known if the water from the near-surface aquifer is being used for drinking, industrial or other purposes. In Phase II of the RI, additional data will be collected on use of these wells.

There are no nearby surface bodies of water that are used as a drinking water source.

Health risks to biological receptors can take any of four major pathways - ingestion of soils or drinking water, direct contact, and inhalation. The drinking water pathway remains of significant concern because TCE may enter lower water supply aquifers through downward migration resulting in contamination of the aquifer. However, this contamination presents a problem only if wells in the area are used for domestic consumption. The depth at which TCE is found in soil provides for a very limited exposure through inhalation, direct contact, or soil ingestion. PCBs found principally in the upper two feet of soil can more realistically impact the surrounding receptors through direct contact and ingestion. PCBs and TCE are addressed individually in the next two sections.

### 8.3 POLYCHLORINATED BIPHENYLS (PCBs)

#### 8.3.1 Public Health Effects

##### 8.3.1.1 Toxicity

PCBs are not capable of causing immediate life-threatening responses in animals except at very high doses. When given as a single oral dose to rats, mice, or rabbits, the dose lethal to 50% of the test species (LD<sub>50</sub>) lies in the range of 1,000 to 16,000 mg/kg of body weight. The acute oral and

dermal LD<sub>50</sub>s for PCBs in rats, mice, and rabbits are given in Tables 8-1, 8-2, and 8-3.

During the 'Yusho incident' in Japan, a poisoning accident caused by ingestion of rice oil contaminated with a commercial brand of polychlorinated biphenyl (Kanechlor 400), the minimum toxic intake for humans was estimated to be 200 micrograms per kilogram of body weight per day (mg/kg bw/day) (Kuratsune, 1972). According to the scheme proposed by the American Industrial Hygiene Association (AIHA), this dosage range for acute or immediate toxicity classifies PCBs as an only slightly toxic to practically nontoxic chemical.

As expected, the most consistent pathological findings associated with short-term exposure to PCBs are alterations to the liver including fatty infiltration, metabolic interference, liver enlargement, and centrilobular necrosis of the liver. Many chlorinated organic chemicals produce liver or kidney injury in mammals. Other effects observed in acute studies include depression and lethargy, decreased pain response, anorexia (loss of appetite), ataxia (unsteady gait), and diarrhea. These are signs of chemical intoxication that are also commonly seen with many other organic chemicals (Chemical Manufacturers Association, 1981).

#### 8.3.1.2 Carcinogenicity

Several findings from animal studies indicated to the National Institute for Occupational Safety and Health (NIOSH) that PCBs are potential carcinogens in humans. These studies also indicated that the less highly chlorinated mixtures (Aroclor 1242 and Kanechlors 300 and 400) may have less carcinogenic potential than the more highly chlorinated mixtures (Aroclors 1254 and 1260 and Kanechlor 500). However, all PCB mixtures adequately tested in rats and mice have shown carcinogenic activity. The details of the experiments with mice and rats are summarized in Tables 8-4 and 8-5. The intakes of PCBs at the lowest dietary level that have produced tumors in rats (10 ppm) would be somewhat comparable to intakes from occupational exposures at 5 to 10

TABLE 8-1  
ACUTE TOXICITY OF PCBs IN SEVERAL STRAINS OF RATS AND MICE\*

Compound Tested	Species and Sex	Route	I.D.		Reference (a)
			g/kg	Body Weight	
Aroclor 1254	Rat (adult, Sherman strain)	Oral	4 - 10		(5)
Aroclor 1260	Rat (adult, Sherman strain)	Oral	4 - 10		(5)
Aroclor 1254	Rat (weanling, Sherman strain)	Oral	1.295		(5)
Aroclor 1260	Rat (weanling, Sherman strain)	Oral	1.315		(5)
Aroclor 1254	Rat (female, Sherman strain)	Intravenous	0.358		(5)
Aroclor 1221	Rat (female, Sherman strain)	Oral	4.00		(6)
Aroclor 1262	Rat (female, Sherman strain)	Oral	11.3		(6)
Aroclor 1240	Rat	Oral	4.25		(7)
Aroclor 1254	Rat (Wistar, 30-day-old, M-F)	Oral	1.3		(8)
Aroclor 1254	Rat (Wistar, 60-day-old, M-F)	Oral	1.4		(8)
Aroclor 1254	Rat (Wistar, 120-day-old, M-F)	Oral	2.0		(8)
Aroclor 1254	Rat (Wistar, 120-day-old, F)	Oral	2.5		(8)
Kaneclor-400	Rat (Wistar, M)	Oral	1.30	(ml kg)	(9)
Kaneclor-400	Rat (Wistar strain, F)	Oral	1.14	(ml kg)	(9)
Kaneclor-400	Mice (CFI strain, M)	Oral	1.875	(ml kg)	(9)
Kaneclor-400	Mice (CFI strain, F)	Oral	1.57	(ml kg)	(9)
Kaneclor-300	Rat (Wistar strain, M)	Oral	1.15		(9)
Kaneclor-300	Rat (Wistar strain, F)	Oral	1.05		(9)
BP-200 biphenyls of dichloride and below	Mice (dd strain, F)	Oral	6.36		(10)
2,4'-Dichlorobiphenyl	Mice (dd strain, F)	Oral	7.86		(10)
Trichlorobiphenyl	Mice (dd strain, F)	Oral	3.06 - 4.25		(10)
Biphenyl or trichloride and below	Mice (dd strain, F)	Oral	9.27		(10)
2,4,3',4'-Tetrachlorobiphenyl	Mice (DVI strain)	Intraperitoneal	2.15		(11)
5-OH derivative of 2,4,3',4'- tetrachlorobiphenyl	Mice (CFI strain)	Intraperitoneal	0.43		(11)
2,3,4,3',4'- Pentachlorobiphenyl	Mice (CFI strain)	Intraperitoneal	0.65		(11)

a - Reference numbers from source

\* - Source: Kimbrough, et al. 1978

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TABLE 8-2  
ORAL LD<sub>50</sub> (RAT)<sup>a,b</sup>

Compound Testing		LD <sub>50</sub> g/kg body weight
Aroclor 1221	(Undiluted)	2.000 - 3.169
Aroclor 1232	(Undiluted)	1.26 - 2.0
Aroclor 1242	(Undiluted)	0.794 - 1.269
Aroclor 1248	(Undiluted)	0.794 - 1.269
Aroclor 1260	(50% soln in corn oil)	1.26 - 2.0
Aroclor 1262	(50% soln in corn oil)	1.26 - 3.16
Aroclor 1268	(33.3% soln in corn oil)	2.5

a - Data of Panel on Hazardous Substances (6)

b - Source: Kimbrough, et al. 1978

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TABLE 8-3  
SKIN LD<sub>50</sub> (RABBITS)<sup>a,b</sup>

Compound Testing		LD <sub>50</sub> g/kg body weight
Aroclor 1221	(Undiluted)	3.98
Aroclor 1232	(Undiluted)	4.47
Aroclor 1242	(Undiluted)	8.65
Aroclor 1248	(Undiluted)	11.0
Aroclor 1260	(50% soln in corn oil)	10.0
Aroclor 1262	(50% soln in corn oil)	11.3
Aroclor 1268	(50% soln in corn oil)	10.9

a - Data of Panel on Hazardous Substances (6)

b - Source: Kimbrough, et al. 1978

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TABLE 8-4  
EVIDENCE FOR CARCINOGENIC EFFECTS OF PCBs IN MICE

Mouse Strain	Sex	No. Treated	No. Surviving	PCB Source	Dietary Level ppm	Average Daily Dose mg/kg/day	Exposure Time (Days)	Liver Nodules			
								Adenofibrosis	Neoplastic Nodules	Hepatoma	Hepatocellular Carcinoma
dd (Ito, et al 1973; Nagasaki, et al. 1972)	M	12	12	Kanechlor 500	500	82.5 <sup>a</sup>	224	-	7/12		5/12
		12	12	Kanechlor 500	250	41.3 <sup>a</sup>		-	0/12		0/12
		12	12	Kanechlor 500	100	16.5 <sup>a</sup>		-	0/12		0/12
				Kanechlor 400	500	82.5			0/12		0/12
				Kanechlor 400	250	41.3			0/12		0/12
				Kanechlor 400	100	16.5			0/12		0/12
				Kanechlor 300	500	82.5			0/12		0/12
					250	41.3			0/12		0/12
		6	6	Control	100	16.5			0/6		0/6
Balb/cJ (Kimbrough and Linder, 1974)	M	50	22	Aroclor 1254	300	49.8	330	22/22	-	9/22	
		50	24	Aroclor 1254	300	49.8 <sup>b</sup>	180 <sup>c</sup>	0/24	-	1/24	
		100	58	Aroclor 1254	-	-	-	0/58	-	0/58	

a - Calculated using food consumption data from Kimbrough and Linder (1974) for Balb/cJ mice which indicates an average of 165 g/kg/day

b - Not calculated directly, but assumed to be similar to group exposed 330 days

c - Maintained on control diet for remaining 150 days of experiment

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TABLE 8-5  
EVIDENCE FOR CARCINOGENIC EFFECTS OF PCBs IN RATS

Strain	Sex	No. Treated	No. Surviving	PCB Source	Dietary Level ppm	Average Daily Dose mg/kg/day	Exposure Time (Days)	Adenofibrosis	Liver Nodules	
									Neoplastic Nodules	Hepatocellular Carcinoma
Donryoe (Kimura and Baba, 1973)	M	10	10	Kanechlor 400	38.5-16	13.5 <sup>c</sup>	339 <sup>a</sup>	-	0/10	-
	F	10	10	Kanechlor 400	38.5-16	17.5 <sup>d</sup>	425 <sup>b</sup>	-	6/10	-
	M	5	5	None	-	-	-	-	-	-
	F	5	5	None	-	-	-	-	-	-
Wistar (Ito, et al 1974)	M		13	Kanechlor 500	1,000	49.0 <sup>c</sup>	378	4/13	5/13	-
			16	Kanechlor 500	500	24.5		0/16	5/16	-
			25	Kanechlor 500	100	4.9		0/25	3/25	-
			10	Kanechlor 400	1,000	49.0		2/10	3/10	-
			8	Kanechlor 400	500	24.5		0/8	0/8	-
			16	Kanechlor 400	100	4.9		0/16	2/16	-
			15	Kanechlor 300	1,000	49.0		2/15	0/15	-
			19	Kanechlor 300	500	24.5		0/19	0/19	-
			22	Kanechlor 300	100	4.9		0/22	1/22	-
			18	None	0	-	-	0/18	0/18	-

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TABLE 8-5  
EVIDENCE FOR CARCINOGENIC EFFECTS OF PCBs IN RATS  
(Continued)

Strain	Sex	No. Treated	No. Sur- viving	PCB Source	Dietary Level ppm	Average Daily Dose mg/kg/day	Exposure Time (Days)	Proliferative Changes		
								Modular Hyperplasia	Hepatocellular Carcinoma and Adenoma	Combined Hematopoietic and Liver
Fischer 344 rat	M	25	24	Aroclor 1254	0	0	-	0/24	0/24	5/24
			24		25	1.38 <sup>e</sup>	735	5/24	0/24	2/24
			24		50	2.75 <sup>e</sup>	735	8/24	1/24	9/24
			24		100	5.5 <sup>e</sup>	735	12/24	3/24	12/24
	F	25	23		0	0	-	0/23	0/23	4/23
			24		25	1.38 <sup>e</sup>	735	6/24	1/21 <sup>e</sup>	13/24
			22		50	2.75 <sup>e</sup>	735	9/22	1/22	8/22
			24		100	5.5 <sup>e</sup>	735	17/24	2/24	9/24

TABLE 8-5  
EVIDENCE FOR CARCINOGENIC EFFECTS OF PCBs IN RATS  
(Continued)

Strain	Sex	No. Treated	No. Surviving	PCB Source	Dietary Level ppm	Average Daily Dose mg/kg/day	Exposure Time (Days)	Liver Nodules		
								Adeno- fibrosis	Neoplastic Modules	Hepatocellular Carcinoma
Sherman (Kimbrough et al 1975)	F	200	184	Aroclor 1260	100	4.9 <sup>f</sup>	630	-	144/184	26/184
	F	200	174	None	-	-	630	-	0/173	1/173
Sherman (Kimbrough et al 1972)	M	10	10	Aroclor 1260	1,000	71.4	240	2/10	-	-
	F	10	10	Aroclor 1260	100	7.2		1/10	-	-
		10	8	Aroclor 1260	500	38.2		1/9	-	-
		10	2	Aroclor 1260	1,000	72.4		4/7	-	-
		10	10	Aroclor 1254	100	6.8		1/10	-	-
	F	10	10	Aroclor 1254	500	36.4		10/10	-	-
		10	10	Aroclor 1254	100	7.5		7/10	-	-
		10	9	Aroclor 1254	500	37.6		9/9	-	-

a - Range 159-530

b - range 244-560

c - range of cumulative intake 450-1800 mg

d - range of cumulative intake 700-1500 mg

e - Data not provided. Calculated from Kimbrough, et al. 1975, in which Sherman rats showed similar weight gain over the same experimental period.

f - Time weighed average calculated from Figure 2 in Kimbrough, et al 1975.

g - Reported as undifferentiated carcinoma of the liver, metastatic

\* - 290 animals total in 10 groups

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mg/m<sup>3</sup>. However, PCBs are slowly eliminated from the body, and the higher chlorinated compounds may accumulate in the body for years. Thus, animal experiments that are limited to 2 years by the life span of the animals may not be informative relative to long term exposure in humans (NIOSH, 1977).

In humans, there are no adequate studies to confirm or deny carcinogenicity although preliminary data suggest that among Yusho patients, deaths due to cancers exceed normal expectations (Kuratsune, 1975; Urabe, 1974), and preliminary studies of two occupationally exposed groups in the U.S. indicate that the occurrence of certain cancers may be excessive. However, the types of cancers found in these studies were inconsistent (NIOSH, 1977).

As discussed earlier, PCBs have been determined to be carcinogenic in mice. Benign and malignant tumors were produced in studies involving oral ingestion. However, inadequate data exists to determine the carcinogenicity of PCBs in humans although limited case studies of actual exposures suggest PCBs are potential carcinogens. PCBs have been classified as probably carcinogenic in humans by the International Agency for Research on Cancer (IARC) and the EPA. Based on positive results in animal studies and inadequate data on humans, the IARC and the EPA classified PCBs in Group 2B and Group B2 of their respective cancer risk classification systems.

#### 8.3.1.3 Mutagenicity

Several PCBs and PCB mixtures, including the 4- and the 2, 2', 5, 5' - isomers and Aroclors 1221, 1254, and 1260, were subjected to the "Ames" test for mutagenicity (Wyndham, 1976). Although 4-chlorobiphenyl showed mutagenic activity in this test, the more highly chlorinated PCBs showed very little activity. Aroclor 1254 did not cause significant chromosomal changes in the testes of rats after it was administered for 7 days at 50 mg/kg/day (Dikshith, 1975). In another experiment (Green and Carr, 1975), neither Aroclor 1254 administered at 300 mg/kg/day for 5 days nor Aroclor 1242 administered at 500

mg/kg/day for 4 days produced chromosomal aberrations in spermatagonial or bone marrow cells of rats. These mixtures also did not produce any evidence of dominant lethal mutations in rats (Green and Sauro, 1975). Although PCBs have little mutagenic potential, they may alter the mutagenicity and carcinogenicity of other compounds by stimulating microsomal enzyme activities (Popper, 1973).

#### 8.3.1.4 Teratogenicity

PCBs have been found in embryonic and fetal tissues of humans (Shiota, 1973; Mesuda, 1974) and experimental animals (Curley, 1973) after introduction of PCBs into the maternal host, evidence that the potential for teratogenic effects exists. Several experiments have been conducted with rats (Curley, 1973; Linder, 1974), rabbits (Villeneuve, 1971), monkeys (Allen, 1974), and dogs and pigs (F.L. Earl, et al., written communication, 1976 as cited by NIOSH, 1977) that are relevant to a discussion of PCB teratogenicity. In these experiments, the PCBs were administered either by gavage or by direct ingestion. Gavage dosages were reported in mg/kg while dietary intakes were reported in ppm. For purposes of comparison, 50 ppm in the diet can be equated to 1 mg/kg/day. This is in the order of magnitude of the maximum rate of PCB intake by Yusho patients. Animal experiments have used PCBs in dietary levels of 1 to 2,500 ppm. Most experiments with PCBs at dietary levels of 100 ppm or more are inconclusive due to interference by fetotoxic effects (Curley, 1973; Linder, 1974; Villeneuve, 1971). In the two-generation feeding study of rats by Linder, et al., 1974, no teratoma were reported. This study covered Aroclor 1254 in the concentration range of 1 to 100 ppm and Aroclor 1260 in the range of 5 to 100 ppm. Although teratoma were not reported, Aroclor 1254 concentrations of 20 to 100 ppm resulted in reduced litter sizes. In rhesus monkeys (Allen, 1974), feeding Aroclor 1248 at 2.5 and 5 ppm caused abortions in some cases and lower than normal birth weights, but no terata were reported. In dogs, teratoma were not found in pups born from dams fed the equivalent of 12 ppm in the diet, but teratogenic effects were present when 48 or 200 ppm equivalents were fed. Sows fed the equivalent of 50 ppm in the same experiment showed high rates of resorptions and, at 10 to 30 times this level, terata were

definitely present in the piglets (F.L. Earl, et al., written communication, 1976, as cited by NIOSH, 1977).

Although retarded prenatal growth and evidence of PCB toxicity were observed in Yusho babies, no terata were reported (Kituchi, 1969; Taki, 1969; Abe, 1975; Yoshimura, 1974; Funatso, 1972). A normal baby was born to a woman exposed to PCBs in her work. The PCB exposure concentrations were not reported but the PCB concentration in her blood was 25 ppm at the time the baby was born (NIOSH, 1977).

These studies indicate that PCBs have teratogenic potential for humans. However, the terata observed in animals occurred at levels at or above doses equivalent to the maximum doses of the Yusho patients and at intake rates 3 to 4 times greater than intakes expected from inhalation at maximum reported occupational exposures (NIOSH, 1977).

### 8.3.2 Environmental Impacts

#### 8.3.2.1 Reactivity

PCBs are considered to be inert to almost all of the typical chemical reactions. PCBs do not undergo oxidation, reduction, addition, elimination, or electrophilic substitution reactions except under extreme conditions. Chlorine can be replaced by reductive dechlorination with metal hydrides but temperatures of 245°C or greater are required.

PCBs appear to undergo alkali - and photochemically - catalyzed nucleophilic substitutions and photochemical free radical substitutions, all of which occur with alkali and water. These reactions may be important mechanisms in the environment.

#### 8.3.2.2 Persistence

Studies of pesticides have demonstrated that soil moisture and evaporation of water have a strong influence on the rate of volatilization of chlorinated hydrocarbons from soils and sand. Haque, et al. (1974) demonstrated that the periodic evaporation of water from Ottawa sand enhanced the total volatilization of Aroclor 1254. When Aroclor 1254 was heated in water at 100°C, the total volatilization of this Aroclor was reduced compared to equivalent dry isothermal conditions; however, the differentiation in volatility between the higher and lower chlorinated biphenyls was increased (Bowes, et al., 1975).

Mackay and Wolkoff (1973) calculated theoretical evaporation rates for various Aroclors from water and predicted very rapid volatilization rates. Under laboratory conditions, PCBs appear to volatilize fairly rapidly from water in aquaria (Uhlken, et al., 1973) as well as from flasks plugged with glass wool (Oloffs, et al., 1972). Under the same conditions, volatilization was markedly reduced in the presence of sediments (Oloffs, et al., 1973). Hence in natural waters, adsorption to sediments may limit the rate of volatilization.

Solubilities of the individual chlorinated biphenyls in water have been studied by several researchers and an inverse correlation between solubility and degree of chlorination has been reported (Wollnofer, et al., 1973; Haque and Schmedding, 1975; Metcalf, et al., 1975). Schoor (1975) has presented evidence that solutions of PCBs in water are in fact stable emulsions of PCB aggregates. This makes true solution equilibria data for PCBs in water difficult to obtain. The true solubility of Aroclor 1254 is less than 0.1 ug/l in fresh water and 0.04 ug/l in marine water.

Chlorobiphenyls are freely soluble in relatively nonpolar organic solvents (Hutzinger, et al., 1974) and lipids in biological systems (Metcalf, et al., 1975). Metcalf, et al. have reported octanol/water partition coefficients in the range of 10,000 to 20,000 for representative tri-, tetra-, and pentachlorobiphenyls (Metcalf, et al., 1975). Octanol/water partition



coefficients ( $K_{ow}$ ) have shown a linear correlation with bioconcentration factors (BCF) in aquatic organisms where:

$$\text{Log (BCF)} = 0.542 \log (K_{ow}) + 0.124 \quad (\text{Neely, et al., 1974}).$$

The weighted average bioconcentration factor for PCBs and the edible portion of all freshwater and estuarine aquatic organisms consumed by Americans is calculated to be 31,200. This number is based on laboratory studies conducted on PCBs in which percent lipids and a steady state BCF were measured (EPA, 1980).

PCBs are strongly adsorbed on solid surfaces, including glass and metal surfaces in laboratory apparatus (Schoor, 1975) and soils, sediments, and particulates in the environment (Haque, et al., 1974; Oloffs, et al., 1973; Crump-Wiesner, et al., 1974; Dennis, 1976; Munson, et al., 1976; Pfister, et al., 1969).

In aquatic environments, PCBs are primarily associated with sediments and are usually found at much higher concentrations in sediments than in water (Young, et al., 1976; Crump-Weisner, et al., 1974; Dennis, 1976). As with other chlorinated hydrocarbons, PCBs are probably highly associated with micro-particulates of 0.15 micrometers in diameter or less (Pfister, et al., 1969).

### 8.3.3 Criteria

The Toxic Substances Control Act (TSCA, P.L. 94-469) was signed into law October 11, 1976. Provisions in Section 6(e) of the law specifically regulate the manufacture, sale, distribution, and disposal of PCBs.

As of October 11, 1987, the manufacture, sale or distribution of PCBs was restricted to sealed systems. Manufacture was banned as of January 1, 1979 and all processing and distribution in commerce ceased July 1, 1979. Allowance for certain exemptions is provided in the law.

The EPA has proposed a water quality criterion for the protection of freshwater and marine life of 0.001 ug/l (EPA, 1976b). The Food and Drug Administration established tolerance levels in foods in 1973 (38 FR 18096) and proposed new tolerance levels further restricting levels in 1977 (42 FR 17487). These levels are presented in Table 8-6.

The occupational exposure limits adopted in 1968 are based on the recommendations of the American Conference of Governmental Industrial Hygienists (ACGIH) (EPA, 1980). They set the time-weighted average (TWA) eight-hour exposure limits to 1.0 mg/m<sup>3</sup> for mixtures containing 42 percent chlorine and 0.5 mg/m<sup>3</sup> for mixtures containing 54 percent chlorine. The recommended standard proposed by NIOSH (1977) is 1.0 ug/m<sup>3</sup> air TWA over a 10-hour day and 40-hour work week.

Since available data suggest that PCBs (Aroclor 1260) show carcinogenic effects in animals and because of the known and potential occurrences of PCBs in drinking water, the EPA has proposed a recommended maximum contaminant level (RMCL) of zero PCBs as a class of compounds. RMCLs are non-enforceable health goals established with an adequate margin of safety to prevent the occurrence of known or anticipated adverse effects (Federal Register, Nov. 13, 1985).

The EPA Water Quality Criteria have been set at 0 ppm for fish and drinking water. A criteria of 0.079 ng/l may be used when zero is unobtainable. This corresponds to a 10<sup>-6</sup> cancer risk factor in humans. Under the Safe Drinking Water Act, health advisories have been set at 0.125 ng/l for 1-day and 0.0125 ng/l for 10-days (EPA, 1985). The FDA regulations are summarized in Table 8-6 and other regulations are summarized in Table 8-7.

TABLE 8-6  
FDA REGULATIONS FOR PCBs\*

I. <u>Temporary tolerances</u>		
Commodity	PCB conc. (ppm)	Proposed Guidelines 1977
Milk (fat basis)	2.5	1.5
Dairy products (fat basis)	2.5	1.5
Poultry (fat basis)	5.0	3.0
Eggs	0.5	0.3
Finished animal feed	0.2	0.2
Animal feed components	2.0	2.0
Fish (edible portion)	5.0	2.0
Infant and junior foods	0.2	pending
Paper food-packaging material without PCB-imperable barrier	10.0 <sup>a</sup>	

a - Administrative guideline, pending hearing

\* - Source: Jelinek and Coreliussen, 1976  
42 FR 17487

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TABLE 8-7  
CRITERIA FOR PCBs WITHIN VARIOUS ENVIRONMENTAL MEDIUMS

Environmental Medium	Criteria	Source
For protection of freshwater and marine life	0.001 ug/l	U.S. EPA, 1976
Food (for human consumption)	see Table 8-6	
Air (8 hours)	1.0 mg/m <sup>3</sup>	American Conference of Governmental Industrial Hygienists, 1968
Air (10 hours)	1.0 ug/m <sup>3</sup>	National Institute for Safety and Health, 1977
Proposed MCLG (Recommended Maximum Containment Level)*	zero	U.S. EPA, 1985
Ambient Water Quality Aquatic Organisms and Drinking Water **	0 (0.079 ng/l)	U.S. EPA, 1980

\* Non-enforceable health goal.

\*\* 0.079 ng/l represents midpoint of risk range.

#### 8.3.4 Conclusions

In general, the pathways of exposure to PCBs include ingestion of soil or drinking water, inhalation, and direct contact. However, lack of PCBs in deeper soils and their potential absence in groundwater at the ITS site indicate that drinking water is not a potential exposure pathway. Inhalation of PCBs is also a limited route of exposure because PCBs do not volatilize and the limited air sampling show the absence of PCBs in airborne soil or dust particles. However, the presence of a working population, resident population, and large transient populations due to significant recreational activities in the area (see Section 8.2) does present a potential pathway of direct contact and ingestion.

#### 8.4 TRICHLOROETHENE (TCE)

##### 8.4.1 Public Health Effects

###### 8.4.1.1 Toxicity

There is no reliable information concerning the toxicological effects in humans of chronic exposure to levels of TCE below the Threshold Limit Value (TLV) of 50 ppm. Based upon acute human exposure information and limited animal testing, it is unlikely that chronic exposure to TCE at levels found or expected in ambient air would result in liver or kidney damage. Such damage has not been generally found even when exposure greatly exceeds the TLV.

Utesch, et al. (1981) exposed rats intermittently to 15,000 ppm (80,700 mg/m<sup>3</sup>) TCE in a manner simulating human solvent abuse. No evidence of liver or kidney damage was observed.

In another study, Albahary, et al. (1959) conducted liver function tests on workers regularly exposed to TCE. No evidence of liver disorders was found in this study either.

The first sign likely to be observed upon exposure to TCE is central nervous system (CNS) dysfunction. In limited, acute controlled human exposures, alterations in task performance have been reported only at levels in excess of 100 ppm. There have been few in-depth studies in rodent species of the effects of TCE on the nervous system and behavior (EPA, 1984).

#### 8.4.1.2 Carcinogenicity

Table 8-8 summarizes the results of a number of laboratory investigations of the carcinogenic potential of TCE in experimental animals. These studies have been done using rats, mice, and hamsters, with TCE administered by inhalation, gavage, subcutaneous injection, and topical application. Of the studies done, the evidence for the carcinogenicity of TCE consists of statistically significant increases of hepatocellular carcinomas in male and female B6C3F1 mice (National Toxicology Program (NTP), 1982; National Cancer Institute (NCI), 1976; Bell, et al., 1978), malignant lymphomas in female NMRI mice (Henschler, et al., 1980), and renal adenocarcinomas, by life table and incidental tumor tests, in male Fischer 344 rats (NTP, 1982). However, inadequacies in both the NTP study in rats and the Industrial Bio-Test Laboratories, Inc. (IBT) study in mice plus limitations in the interpretation of the data in the Henschler, et al. study in mice may preclude any conclusive correlation between these animal studies and carcinogenicity in humans.

The EPA Risk Assessment Forum has classified TCE as a probable human carcinogen (Group B2) on the basis of animal studies indicating carcinogenicity in mice by inhalation and weak mutagenicity. The IARC has determined, however, that adequate data are not available to determine the human carcinogenicity of TCE. The IARC cancer risk classification for TCE is Group 3 (Federal Register, Nov 13; 1985).

TABLE 8-8  
TCE CARCINOGENICITY BIOASSAYS IN ANIMALS

Study	TCE chemical purity	Species	Dose levels, route	Results
NTP 1982	Purified	Mice, B6C3F1 Males Females	1000 mg/kg/day gavage, 103 wk	Treatment-related hepatocellular carcinomas in males and females
		Rats, Fischer 344 Males Females	500, 1000 mg/kg/day gavage, 103 wk	Renal adenocarcinomas in treated males
NCI 1976	Technical grade	Mice, B6C3F1 Males Females	1119, 2339 mg/kg/day 869, 1739 mg/kg/day gavage, 78 wk	Treatment-related hepatocellular carcinomas in males and females
		Rats, Osborne- Mendel Males Females	549, 1097 mg/kg gavage, 88 wk	Negative
Bell et al. (MCA) 1978	Technical grade	Mice, B6C3F1 Males Females	100, 300, 600 ppm inhalation, 24 mo	Increased incidence of hepatocellular carcinomas in males and females with dose
		Rats, Charles River Males Females	100, 300, 600 ppm inhalation, 24 mo	Negative
Maltoni 1979	Purified	Rats, Sprague- Dawley Males Females	250, 50 mg/kg gavage, 52 wk	Negative
Henschler et al. 1980	Purified	Mice, Han: NMRI Males Females	100, 500 ppm inhalation, 78 wk	Increased incidence of malignant lymphomas in females
		Rats, Han:Wist Males Females	100, 500 ppm inhalation, 78 wk	Negative
		Hamsters, Syrian Males Females	100, 500 ppm inhalation, 78 wk	Negative

TABLE 8-8  
TCE CARCINOGENICITY BIOASSAYS IN ANIMALS  
(Continued)

Study	TCE chemical purity	Species	Dose levels, route	Results
Van Duuren et al. 1979, 1983	Purified	Swiss mice ICR/He Female	1 mg, 3x/wk, 581 d topical	Negative
		Female	1 mg, 3x/wk, 14 d 2.5 ug phorbol myristate acetate, topical 452 d	Negative
		Female	0.5 mg sc/wk, 622d	Negative
		Female Male	0.5 mg, once wk gavage, 622 d	Negative
	Purified TCE epoxide	Female	1 mg TCE epoxide, 3x/wk, 2.5 ug phorbol myristate acetate, topical, 452 d	Negative
		Female	2.5 mg TCE epoxide 3x/wk, topical for 526 d	Negative
		Female	0.5 mg TCE epoxide once wk, sc, 547 d	Negative
NTP 1982	Purified	Rats, Osborne- Mendel Marshall 540, August 28807, ACI	Gavage, 104 wk	In progress
Meltoni 1979	Purified	Mice, B6C3F1 Swiss albino	Inhalation, 78 wk	In progress
		Rats, Sprague - Dawley	Inhalation, 104 wk	
Henschler et al. 1980	Purified and stabilized	Swiss mice ICR/He	Gavage, 78 wk	In progress



#### 8.4.1.3 Mutagenicity

Commercial grade TCE has shown suggestive, positive responses in gene mutation studies using bacteria, fungi, higher plants, and mice. These responses occurred with metabolic activation only, suggesting the involvement of one or more metabolites of TCE. Marginally increased incidences of revertant counts were only observed at high doses. TCE was not shown to cause structural chromosomal aberrations in the one test conducted to assess this endpoint. Thus, commercially available TCE is only weakly mutagenic at most.

Other tests provide evidence that commercial grade TCE damages DNA. Suggestive and weak-positive responses have been observed in yeast (gene conversion and mitotic recombination), mice (Unscheduled DNA Synthesis), and humans (Sister-Chromatid Exchange and Unscheduled DNA Synthesis). Metabolic activation was again required to obtain the positive responses. Certain metabolites of TCE have been tested for their mutagenic potential, and suggestive positive effects have been shown. TCE or a metabolite(s) may be minimally capable of binding to DNA.

TCE causes weak increases in morphological abnormalities in sperm providing evidence that it reaches the gonads. A synopsis of the results of these studies is presented in Table 8-9.

The available data suggest that commercial grade TCE is a weakly active indirect mutagen, causing effects in a wide range of organisms, including humans. Many commercial grades of TCE contain epoxide stabilizers. The available data on pure TCE do not allow a conclusion to be drawn about its mutagenic potential. The observations that TCE causes adverse effects in the testes of mice suggest TCE may cause adverse testicular effects in man, also, provided that the pharmacokinetics of TCE in humans also results in its distribution to the gonads. However, mutagenic potential cannot be ruled out. The available data suggest TCE would be a very weak, indirect mutagen (EPA, 1984).

TABLE 8-9  
SUMMARY OF TESTS FOR MUTAGENICITY OF TCE

Test Category	Organism	Type of Test	Purity of TCE	Results	Comments	Reference
I. Gene Mutations	<u>Salmonella typhimurium</u>	Reverse mutations <u>in vitro</u>	Technical-grade	-	No control to test effectiveness of S9 mix. No precautions to prevent evaporation.	Henschler et al 1977
		Plate incorporation tests	Technical-grade	+	Two-fold increase	Margard, 1978
			Purified	-		Margard, 1978
			Anesthetic-grade	-		Waskell, 1978
			Purified <sup>a</sup>	*	1.8-fold increase	Bartsch et al 1979
		Vapor exposure	Purified <sup>a</sup>	*	1.3-fold increase	Baden et al 1979
			Reagent <sup>a</sup> grade	*	1.7-fold increase	Simmon et al 1977
	<u>Escherichia coli</u>	Forward and reverse mutations	Analytical-grade	*	Positive for reverse mutations only at arg locus (two-fold increase)	Greim et al 1975
	<u>Schizosaccharomyces pombe</u>	Forward mutations (Host-mediated assays)	Technical-grade	*	1.7-fold increase	Lopriano et al 1979

+ = Positive  
- = Negative  
\* = Suggestive  
<sup>a</sup> = No detectable epoxides  
x = Inconclusive

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TABLE 8-9  
SUMMARY OF TESTS FOR MUTAGENICITY OF TCE  
(Continued)

Test Category	Organism	Type of Test	Purity of TCE	Results	Comments	Reference
I. Gene Mutations (cont'd)	<u>Schizosaccharomyces pombe</u> (cont'd)		Purified	-		Loprieno et al 1979
			Purified	-	Epichlorohydrin and epoxybutane were also negative	Rossi et al 1983
			Purified <sup>a</sup>	-		Mondino 1979
	<u>Saccharomyces cerevisiae</u>	Reverse mutations (in vitro)	Technical-grade	x	High toxicity	Shahin and Von Borstel, 1977
			ACS reagent-grade	+	Four-fold increase both host-mediated assay and liquid suspension test	Bronsatti et al 1978
			Technical-grade	+	Two-fold increase	Callen et al 1980
	<u>Tradescantia</u>	Forward mutations	Unknown	*		Schairer et al 1978
	<u>Drosophila melanogaster</u>	Sex-linked recessive lethals	Technical-grade	-		Abrahamson and Valencia 1980
			Technical-grade	-		Beliles et al 1980
	<u>Mouse</u>	Spot test	Technical-grade	+	Six-fold increase	Fahrig et al 1977

+ = Positive  
- = Negative  
\* = Suggestive  
a = No detectable epoxides  
x = Inconclusive

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TABLE 8-9  
SUMMARY OF TESTS FOR MUTAGENICITY OF TCE  
(Continued)

Test Category	Organism	Type of Test	Purity of TCE	Results	Comments	Reference
II. Chromosomal Aberrations	<u>Drosophila melanogaster</u>	Chromosome loss	Technical-grade	-		Beliles et al 1980
	Rat	Bone marrow	Technical-grade	x	Positive control given by different route of exposure. Doses of TCE may have been too low.	Beliles et al 1980
	Mouse	Dominant lethal	Purified <sup>a</sup>	-		Slacik - Erben et al, 1980
		Micronucleus	Analytical-grade	x	Positive response reported by authors may be due to artifacts in mature erythrocytes.	Duprat and Gradiski, 1980
	Human	Breaks	Occupational exposure	-		Konietzko et al 1978
		Hypodiploid cells	Occupational exposure	x	Unmatched control group. Hypodiploid cells can be caused by preparation of chromosomes.	Konietzko et al 1978
III. Other Studies Indicative of Mutagenic Damage	<u>Saccharomyces cerevisiae</u>	Gene conversion	ACS reagent-grade	+	Two-fold increase with metabolic activation.	Bronzetti et al 1978

+ = Positive  
- = Negative  
\* = Suggestive  
a = No detectable exposures  
x = Inconclusive

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TABLE 8-9  
SUMMARY OF TESTS FOR MUTAGENICITY OF TCE  
(Continued)

Test Category	Organism	Type of Test	Purity of TCE	Results	Comments	Reference
III. Other Studies Indicative of Mutagenic Damage (cont'd)	<u>Saccharomyces cerevisiae</u> (cont'd)	Gene conversion (cont'd)	Technical <sup>a</sup> -grade	+	Five-fold increase	Callen et al 1980
		Mitotic recombination	Technical <sup>a</sup> -grade	+	Four-fold increase	Callen et al 1980
	Mouse	Sister chromatid exchange	Anesthetic-grade	-	No positive controls. No evidence of toxicity.	White et al 1979
	Human	Sister chromatid exchange	Occupational exposure	*	Increases correlated with presence of TCE metabolites tri-chloroethanol and trichloroacetic acid in the blood.	Gu et al 1981
	Rat	Unscheduled DNA synthesis	Technical-grade	*	1.5 to 1.8-fold increases	Beliles et al 1980
			Technical-grade	x		Perocco and Prodi, 1981
		HPC DNA repair assay	Stabilized	-	Vinyl chloride only weakly active.	Williams and Shimada, 1983
			Unstabilized	-		Williams and Shimada, 1983
			Technical-grade	-		Williams 1983

+ = Positive  
- = Negative  
\* = Suggestive  
<sup>a</sup> = No detectable epoxides  
x = Inconclusive

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TABLE 8-9  
SUMMARY OF TESTS FOR MUTAGENICITY OF TCE  
(Continued)

Test Category	Organism	Type of Test	Purity of TCE	Results	Comments	Reference
III. Other Studies Indicative of Mutagenic Damage (cont'd)	Mouse	HPC DNA repair assay	Technical- grade	+	8- to 20- fold increases	Williams 1983
IV. Evidence TCE Reaches the Conads	Mouse	Morphological sperm abnormalities	Anesthetic- grade	*	1.8-fold increase	Land et al 1979
			Technical- grade	+	Three-fold increase	Beliles et al 1980
V. Mutagenicity of Metabolites						
A. TCE-oxide						
	<u>Salmonella</u> <u>typhimurium</u>	Reverse mutations		-		Kline et al 1982
	<u>Escherichia</u> <u>coli</u>	Reverse mutations		-		Kline et al 1982
		Differential killing of repair deficient bacteria		+	40% decreases in survival of Pol- vs. Pol+ cells	Kline et al 1982
B. Trichloroethanol						
	<u>Salmonella</u> <u>typhimurium</u>	Reverse mutations		-		Waskell 1978
	Human lymphocytes	Sister chromatid exchange		*		Gu et al 1981

+ = Positive  
- = Negative  
\* = Suggestive  
a = No detectable epoxides  
x = Inconclusive

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TABLE 8-9  
SUMMARY OF TESTS FOR MUTAGENICITY OF TCE  
(Continued)

Test Category	Organism	Type of Test	Purity of TCE	Results	Comments	Reference
V. Mutagenicity of Metabolites (cont'd)						
C. Trichloroacetic Acid						
	<u>Salmonella typhimurium</u>	Reverse mutations		-		Waskell 1978
D. Chloral Hydrate						
	<u>Salmonella typhimurium</u>	Reverse mutations		+	1.6-fold increase	Waskell 1978
	Human lymphocytes	Sister chromatid exchange		+		Gu et al 1981

+ = Positive  
- = Negative  
\* = Suggestive  
a = No detectable epoxides  
x = Inconclusive

#### 8.4.1.4 Teratogenicity

Because of its widespread use, TCE has been studied for teratogenic potential. Teratology studies have been performed in rats, mice, and rabbits using doses of TCE which, in some studies, produce slight signs of maternal toxicity. Also, TCE is known to be metabolized in the maternal host (and possibly also in the fetal liver) by hepatic metabolizing enzymes to chloral hydrate and then to trichloroethanol and trichloroacetic acid. These metabolites, particularly trichloroethanol, have also been shown to readily cross the human placenta into the fetal circulatory system and the amniotic fluid (Bernstine and Meyer, 1953; Bernstine, et al., 1954) and also into the breast milk of nursing mothers (Bernstine, et al., 1956). Chloral hydrate and its metabolite, trichloroethanol, have been used commonly as hypnotics, including use during pregnancy, with no reported adverse teratogenic, fetotoxic, or reproductive effects (Goodman and Gilman, 1980).

Trichloroethanol has been administered to three animal species at various stages of pregnancy, at levels as high as 700 mg/kg/day, without dose-related effects (Physicians Desk Reference, 1981). Other studies in chicken embryos (Fink, 1968; Elovaara, et al., 1979) have indicated that TCE disrupts embryo development. However, because administration of TCE directly into the air space of chicken embryos is not comparable to administration of the dose to animals with a placenta, it is not possible to correlate these results to the potential of TCE to cause adverse effects in animals or humans.

The chicken embryo study is summarized in Table 8-10 along with several other studies of fetotoxic and teratogenic potential of TCE. Well-designed inhalation exposure studies in the mouse (300 ppm) and rat (300, 500 and 1800 ppm: 1614, 2690, and 9684 mg/m<sup>3</sup>) demonstrate no significant maternal toxicity, embryo toxicity, teratogenicity, or post-natal behavioral effects. In rabbits, 500 ppm (2690 mg/m<sup>3</sup>) inhalation exposure provides no evidence of maternal toxicity or embryo toxicity; however, the assessment was based on only a few hydrocephalic fetuses observed in one group (of four) exposed to TCE (EPA, 1984).



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TABLE 8-10  
SUMMARY OF ANIMAL STUDIES OF FETOTOXIC AND TERATOGENIC POTENTIAL OF TCE

	TCE purity	Species	Conditions (mode of administration, dosage, and duration of exposure)	Measures	Results
Fink (1968)	Unknown	Chick embryo	Vapor exposure, 10,000 ppm	Mortality anomalies	Increase Slight increase
Elovaara (1979)	Reagent grade	Chick embryo	Injected; 1 - 100 umole per egg in 25 ul olive oil	LD <sub>50</sub>	50-100 umole/egg (16% malforma- tions in total survivors)
Schwetz et al (1975)	Technical 99.24% TCE 0.76% stabi- lizers and impurities (Neu-tri)	S - D rat	Inhalation; 300 ppm, 7h/d on 6 - 15-d gestation	Embryo toxicity	+
		S - W mouse		teratogenicity (maternal toxicity)	- (+)
Bell (1977)	Technical (Trichlor 132)	CR - SD rat	Inhalation; 300 ppm, 6h/d on 6 - 15-d gestation	Embryo toxicity, teratogenicity (maternal toxicity)	+ - (+)
Dorfmueller et al (1979)	Technical 99%+ TCE 0.2% epichloro- hydrin (Neu-tri)	Rat (Long-Evans)	Inhalation, 1800 ppm	Embryo toxicity,	+
			a) Premating; 6h/d, 5d/wk for 2 wk	teratogenicity, off- spring behavioral	-
			b) Premating for 2 wk + first 20-d gestation, daily	evaluation (maternal toxicity)	(+)
Beliles et al (1980)	Technical 99.9%	CR - SD Rat Rabbit	c) First 20-d gestation, daily		
			Inhalation; 500 ppm, 7 h/d, 5d/wk Premating 3 wk + first 18-d gestation, daily (rat) + first 21-d gestation, daily (rabbit)	Embryo toxicity, teratogenicity (maternal toxicity)	+ - (+)

At present, no definitive clinical evidence of fetotoxicity or teratogenicity from TCE exposure has been reported. Therefore, the available information does not indicate that the fetus is uniquely susceptible to the effects of TCE. It should be noted, however, that additional studies of appropriate rodent species are needed to more fully examine the teratogenic potential of TCE (EPA, 1984).

#### 8.4.2 Environmental Impacts

##### 8.4.2.1 Reactivity

TCE is photochemically reactive and autooxidizes upon catalysis by free radicals. Autooxidation is greatly accelerated by high temperatures and exposure to ultraviolet radiation. Decomposition products include dichloroacetyl chloride, phosgene, carbon monoxide, hexachlorobutene, and hydrochloric acid (HCl). Some of its degradation products, e.g., HCl, are corrosive to metals (McNeill, 1979).

Decomposition is catalyzed when TCE comes in contact with aluminum metal. The HCl produced reacts with aluminum to yield aluminum chloride ( $AlCl_3$ ) which catalyzes the formation of hexachlorobutene (McNeill, 1979). Sufficient quantities of aluminum have been reported to cause violent decomposition of TCE (Metz and Roedy, 1949). TCE is nonflammable under ordinary conditions; however, mixtures of TCE (10.3 to 64.5 percent) and oxygen will ignite at temperatures above  $25.5^{\circ}C$  (Jones and Scott, 1942).

##### 8.4.2.2 Persistence

Many processes occur in the troposphere which can alter the atmospheric levels of TCE. Once emitted into the troposphere, vertical and horizontal mixing occurs. Transport is highly dependent upon the length of time TCE remains in the troposphere. This is determined largely by the extent to which TCE reacts with hydroxy free radicals (OH), the principal scavenging

mechanism for TCE and many other halogenated compounds in the atmosphere (EPA, 1984).

On the basis of the observed rate of reaction of TCE with hydroxy radicals in a reaction cell, Edney, et al. (1983) calculated an atmospheric lifetime for TCE of about 54 hours. A hydroxy concentration in the troposphere of  $10^6$  molecules/cm<sup>3</sup> was assumed. Evidence provided by Singh, et al. (1979), further suggests that TCE is short-lived in the troposphere. These researchers estimated a residence time of about two weeks, an estimate based on a seasonally-averaged OH concentration of  $4 \times 10^5$  molecules/cm<sup>3</sup> and a rate constant (National Bureau of Standards, 1978), at 265°K, of  $2.3 \times 10^{-12}$ . Singh, et al. (1979) estimated that, given an OH concentration of  $1 \times 10^6$  molecules/cm<sup>3</sup>, 20 percent of the TCE in ambient air can be destroyed each day. Crutzen, et al. (1978) estimated a residence time of 11 days for TCE. Derwent and Eggleton (1978) estimated the lifetime of TCE at approximately 15 days. The percentage of the ground level emissions of TCE that was estimated to survive free radical attack was 0.4 percent.

As expected, seasonal variations in OH concentrations, important for longer-lived species, do not appear to play a significant role in the tropospheric survival of TCE. Altshuller (1980) calculated that in January (when OH levels and solar flux are low) 0.6 days would be required for the photochemical decomposition of 1 percent of the ambient TCE. In July (when OH levels and solar flux are high), only 0.07 days is required.

TCE was observed to have a slow decomposition rate in dilute aqueous solution (Dilling, et al., 1975). Its half-life (in the absence of light) was 10.7 months at ambient temperatures and 54 percent of the TCE had decomposed within 12 months. However, when the solution was exposed to sunlight, 75 percent of the TCE decomposed in 12 months. A correction for the amount of TCE that volatilized into the air space above the solution was not employed. On the other hand, Pearson and McConnell (1975), in their determinations of the

hydrolytic decomposition, extrapolated to zero volatilization. Their estimate was a half-life of 30 months.

The major route of removal of TCE from water is volatilization. Dilling, et al. (1975) have shown that the loss of TCE from an agitated diluted aqueous solution occurs exponentially with an evaporative half-life of approximately 20 minutes. Scherb (1978) measured the volatilization of TCE from an aeration channel in a wastewater treatment plant and found the half-life to be three hours. The rate of volatilization of TCE from surface waters in the environment has been reported by Zoeteman, et al. (1980). TCE was found to have a half-life of one to four days in the Rhine River and 30 to 40 days in the tidal estuary. Smith, et al. (1980) have shown that the rate of volatilization of TCE and other low-molecular-weight compounds from various bodies of waters is a function of reaeration rates. From the work of Smith, et al. (1980), it is estimated that the half-life for TCE in surface waters ranges from three hours for rapidly moving shallow streams to 10 days or longer for ponds and lakes (Table 8-11).

#### 8.4.3 Criteria

In 1978, NIOSH recommended that the Occupational Safety and Health Administration (OSHA) revise worker exposure limits to 25 ppm TCE with a ten-hour TWA. The ACGIH determined a TCE TLV of 100 ppm. The maximum allowable concentration in air is 200 ppm provided the TLV does not exceed 100 ppm. For a maximum cumulative exposure of five minutes in any two hour period, the maximum peak above the maximum allowable concentration is 300 ppm.

The EPA Water Quality Criteria for TCE has been set at zero for fish and drinking water. When zero is unobtainable, a criteria corresponding to a  $10^{-6}$  cancer risk factor is allowed. For TCE this criteria is 2.7 ug/l. Under

TABLE 8-11  
ESTIMATED HALF-LIFE OF TCE IN SURFACE WATERS

Water Type	TCE half-life (days)
Pond	11
Lake	4 to 12
River	1 to 12

Source: Calculated from information in Smith et al. (1980).

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the Safe Drinking Water Act, health advisories have been set at 2.0 mg/l for 1-day, 0.2 mg/l for 10-days and 0.075 mg/l for longer than 10 day exposure levels (EPA, 1985). EPA (1986) has also proposed a maximum concentration limit (MCL) of 0.005 mg/l for TCE. In addition, 2.8 mg/l has been identified by EPA (1986) as as reference concentration for TCE for carcinogenicity.

#### 8.4.4 Conclusions

Potential pathways for exposure to TCE includes inhalation, ingestion of soil or drinking water, and direct contact. Based upon the results of health effects studies, the most probable pathways are inhalation and ingestion of soil and drinking water. A full evaluation of the drinking water pathway requires obtaining the results of Phase II of the RI which will identify use of existing shallow wells and provide additional data on the concentrations of TCE in deeper soil zones and in lower aquifers.

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SECTION 9  
RECOMMENDED CLEANUP LEVEL  
AND VOLUME OF SOIL REQUIRED FOR REMEDIATION

This section presents an assessment of the site under its present conditions and continues with the development of a recommended cleanup level. Using these recommended action levels, the volume of contaminated soil to be remediated is estimated.

9.1 ASSESSMENT OF PRESENT CONDITIONS

As noted in Section 8.0, the contaminants of concern at the ITS site are PCBs and TCE. The following discussion will principally deal with the inhalation and direct contact pathways of exposure. The groundwater pathway for PCBs is not a concern due to the low solubility and tendency of PCBs to adhere to finer soil particles. This fact is confirmed by ITS site data which show that most of the PCBs contamination is limited to the upper two feet of soil. On the other hand, TCE contamination of the upper two feet of soil is very limited and most of the TCE contamination at the site is limited to deeper soils and groundwater. This particular nature of the contamination problem at the site has led to identification of two distinct problems at the site which may require remediation. The first problem is the contamination of shallow soils with PCBs, and the second is contamination of deeper soils and groundwater with TCE. The TWC and EPA have decided to conduct two feasibility studies corresponding to these two distinct contamination situations at the site.

In order to better define the groundwater contamination at the ITS site, Phase II of the RI will provide additional data on the occurrence of TCE in deeper soils and the lower aquifers in addition to confirming the uses of water obtained from shallow wells in use near the site.

#### 9.1.1 PCB Contamination

Based upon the low volatility of PCBs, ingestion is the primary exposure pathway to PCBs at the ITS site. A risk assessment of the site was conducted using 350 ppm PCBs as the concentration present in the surficial soils. Other assumptions for the calculations are:

- An average soil ingestion rate of 0.00082 g/kg body weight/day over a 40 year period of a 70 year lifetime for an average worker of 70 kilograms,
- Exposure time based on a 250 day work year, outdoors 50% of the time, and
- A cancer potency of  $7 \times 10^6$  (mg PCBs/kg body weight/day)<sup>-1</sup>.

The computed excess cancer risk is  $6.8 \times 10^{-4}$  (or approximately 1 out of 1500).

PCB contamination caused by PCB spills and their subsequent cleanup are governed by TSCA as given in the Federal Register (April 2, 1987). For the ITS site, policies and cleanup levels developed under TSCA will be used as one of the Federal ARARs. Thus, the discussion presented in this section will be of TSCA and its pertinence to the ITS site.

TSCA policy requires PCBs to be cleaned up to different levels, depending on such factors as:

- Spill location,
- Potential for receptor exposure to residual PCBs remaining after cleanup,
- Initial concentrations of spilled PCBs, and
- Nature and size of the population potentially at risk of exposure.

The most stringent standards for PCB spill cleanup apply to areas of greatest potential for human exposure. Less stringent requirements apply to areas where

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the types and degrees of contact present lower potential exposures. The least stringent requirements apply to areas where there is little potential for direct human exposure.

The characteristics of a restricted, industrial-type location are described by TSCA as follows:

- The site must be at least 0.1 kilometer from a residential/commercial area.
- Access is restricted in some manner.
- The PCB spill has resulted in outdoor contamination of soil, sand, gravel and other similar materials.

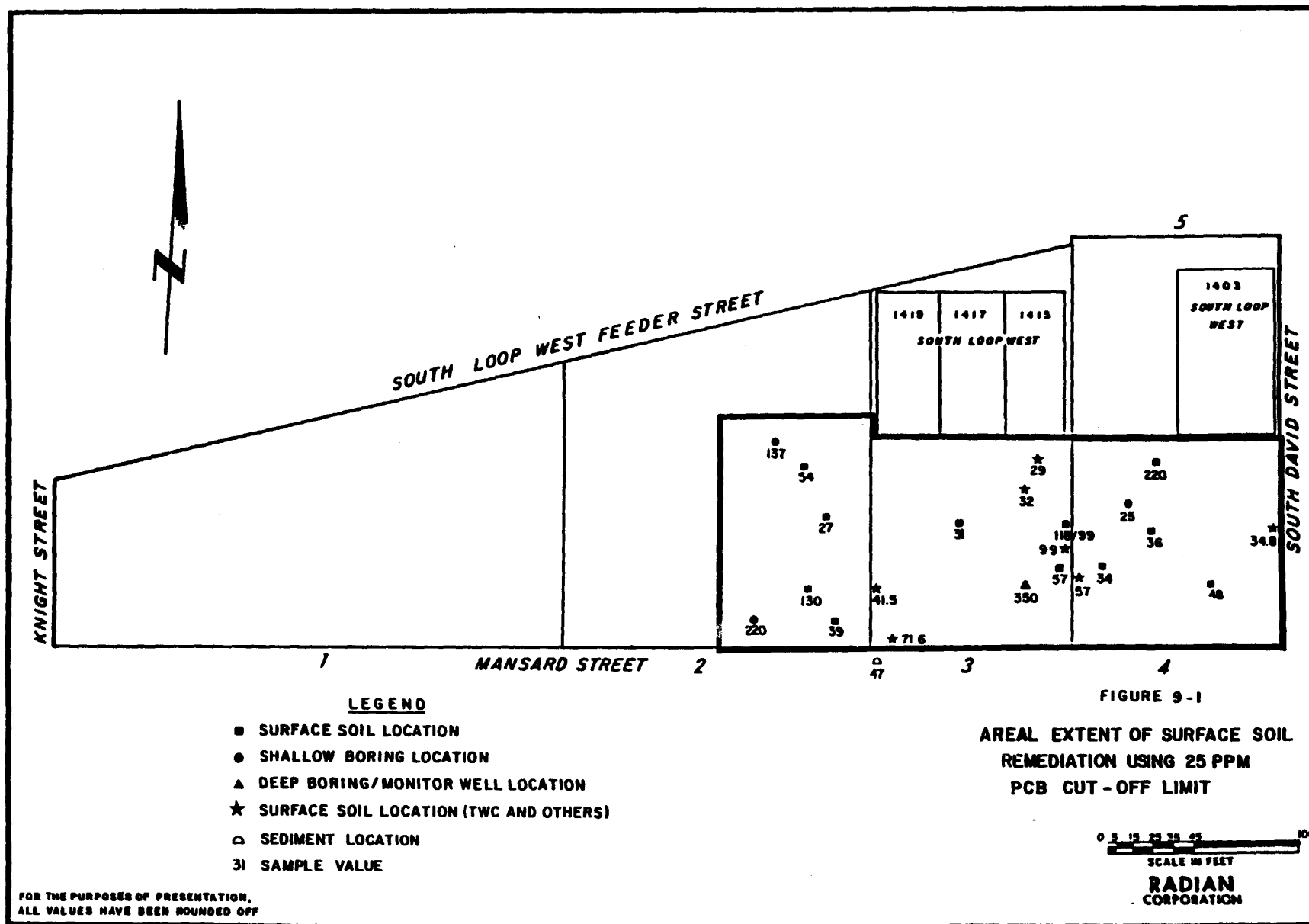
The EPA's health risk policy analysis shows that a cleanup effort resulting in PCB levels in the soil of 25 ppm or less would present less than  $1 \times 10^{-7}$  level of oncogenic risk to people on-site who work more than 0.1 km from the actual spill site (assuming that the spill area covers less than 0.5 acre).

The ITS site has characteristics similar to those listed above, but varies from these conditions in the following ways:

- Office/warehouse space on-site is currently rented to light industrial/commercial activities.
- Other light industrial/commercial activities currently are in operation within 0.1 kilometer (328 feet) of the site.
- The spill covers an area of approximately 0.71 acre.
- The site has no natural or man-made barriers to restrict access.

However, the significance of these variances is considered by EPA Region 6 to be minimal.

Figure 9-1 shows sampling points having PCB concentrations of greater than 25 ppm. All available data show that PCBs of 25 ppm or greater concentra-



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tions are limited to the upper two feet of soil. Thus, under present conditions, or the no remedial action alternative (presented in more detail in the FS), the ITS site violates one of the Federal ARARs.

#### 9.1.2 TCE Contamination

As noted in Section 8.0, TCE has been identified as carcinogenic. Section 8.4 notes ambient water quality criteria, MCLs, and references TCE concentrations for carcinogenicity via the drinking water pathway. Thus, a potential ARAR exists for drinking water contamination levels. However, as noted previously, the ingestion via drinking water pathway will be investigated subsequently to completion of Phase II of the RI. For the sake of completeness, no significant surface water bodies exist near the site that are used as a source of drinking water and that could potentially be impacted by contamination from the site.

In conjunction with EPA Region 6 and the Agency for Toxic Substances and Disease Registry (ATSDR), an analysis was conducted to develop the potential cancer risk from exposure to the maximum TCE concentrations observed within the upper two feet of soil (150 ppm observed at SB-7) via the soil ingestion route. The computation of risk was based on the following assumptions:

- o Land use continues as industrial or highly commercial;
- o Average lifetime soil ingestion rates for a 70 kilogram (kg) man over a 40 year period of a 70 year life time is 0.00082 gm/kg body weight per day;
- o Total fraction of worker exposure time is 0.34, based upon 250 workdays per year and outdoors presence at 50% of the time;
- o Cancer potency factor for TCE is  $2.2 \times 10^{-2}$  kg-day/mg; and
- o TCE at a concentration of 150 mg/kg (or 150 ppm) is available for ingestion throughout the exposure duration.

The computations for this analysis are given in Appendix F-1. The computed excess cancer risk is less than the  $10^{-6}$  target level.

The top several inches of soil are the depth of greatest interest when calculating the risk due to soil ingestion. Since TCE volatilizes easily, the possibility of having TCE at the high concentrations used in the above calculation during the assumed period of exposure is minimal. The RI investigation supports this observation, i.e., the highest TCE concentration observed in surface soils at the site is 1.6 ppm. Even the shallow boring program shows the highest concentration of TCE to be 150 ppm which was taken from a sample composited over a depth of 0 to 2 feet in SB-7. The other shallow boring samples have yielded TCE concentrations ranging from none detected to 87 ppm.

A second computation (also shown in Appendix F-1) was completed using the same assumptions as listed above to determine a soil TCE concentration corresponding to an excess cancer risk of  $10^{-6}$ . This was computed to be 161 ppm TCE.

A similar analysis conducted to assess the risks posed by the inhalation and ingestion of TCE was submitted to ATSDR for review. ATSDR noted that the analysis was extremely conservative. Some of the conservative assumptions noted by ATSDR are:

- o Depth of soil cover was assumed to be 1 centimeter,
- o TCE concentrations are uniformly distributed over the entire site, and no compensation is allowed for areas having no or little TCE contaminated soil,
- o The cancer potency factor used in this analysis is twice the value suggested by the EPA Public Health Manual,
- o TCE will be available through the entire duration of exposure, and
- o TCE is absorbed at 100% efficiency.

The cleanup level calculated for simultaneous inhalation and ingestion of TCE was computed to be 160 ppm. ATSDR concluded that based upon the conservative assumptions used in the calculation, a cleanup level of 161 ppm for TCE will provide more than enough protection for both the ingestion and inhalation routes. The corresponding calculations are shown in Appendix F-1.

For short-term exposures, the applicable standards are the 10-hour TWA which is 25 ppm and the ACGIH TLV which is 50 ppm TCE. The highest concentration of TCE observed in the first nine feet of soil at the ITS site (these are the soils that may be subjected to short term activities such as excavation and trenching) is 150 ppm (SB-7). Considering the potential dispersion of TCE from the soil at ground level to breathing level, it is not expected that either of these short-term standards will be violated at the site.

In conclusion, the site in its present state (identical to that of the no action alternative) does not pose a TCE cancer risk in excess of  $10^{-6}$  for the soil ingestion and inhalation pathways. As noted earlier, evaluation of the risks posed by TCE contamination of groundwater awaits the completion of Phase II of the RI.

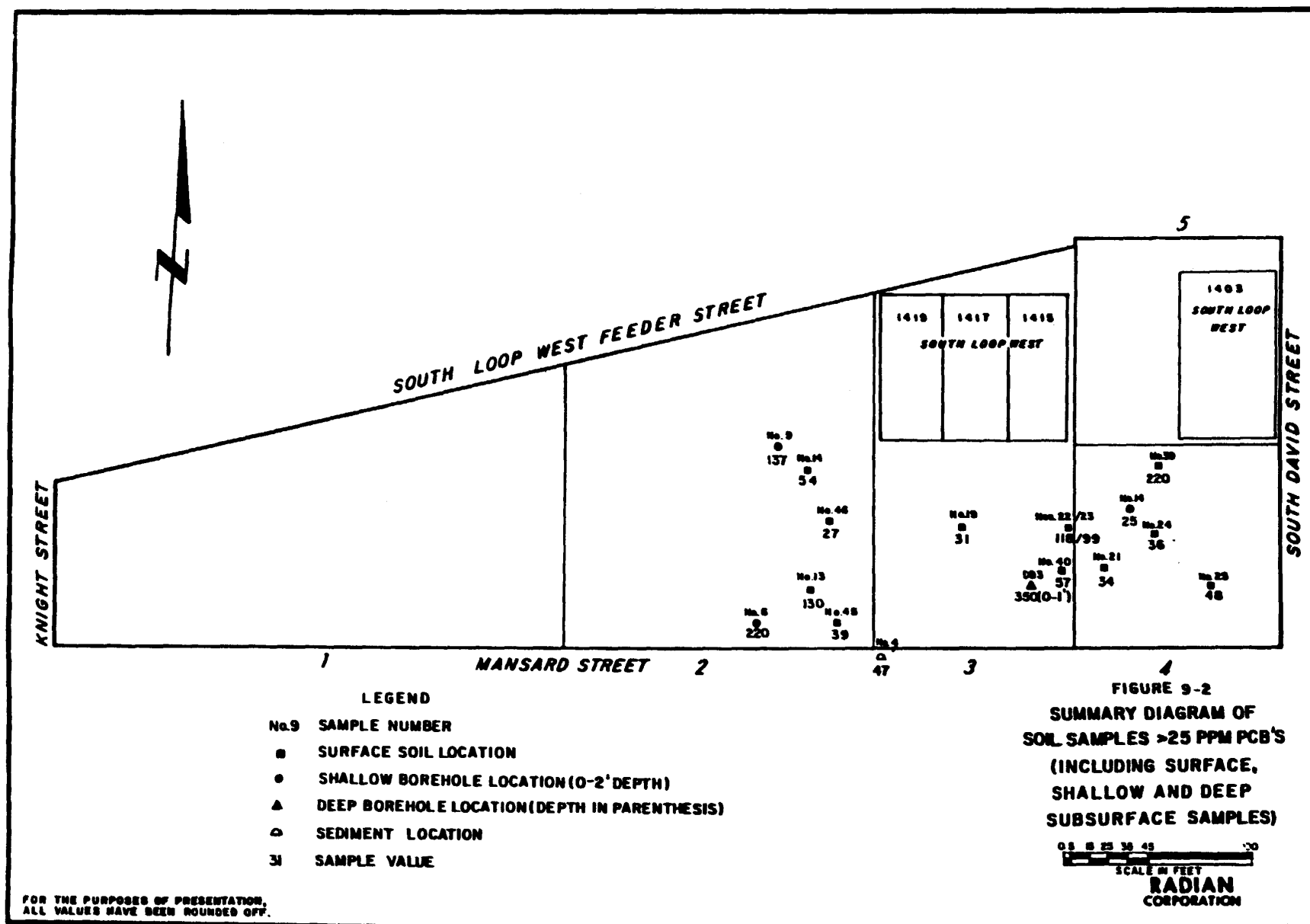
## 9.2 VOLUME OF CONTAMINATED SOIL TO BE REMEDIATED

As per the discussion presented in Section 9.1, the remediation of surface and shallow subsurface soil is required to comply with PCB cleanup criteria. As per ATSDR, the TCE cleanup criteria is 161 ppm and all of the observed data for surface and shallow subsurface soil are less than this value. However, soil remediation schemes based upon PCB cleanup criteria will also remove the areas known to exhibit TCE contamination. Furthermore, the existence of two feet of clean soil on top of the contaminated soils will essentially eliminate the risks posed by the TCE found in shallow subsurface soils. The following discussion, thus, restricts itself to identification of soils containing PCBs greater than 25 ppm.

Figure 9-2 shows the boundaries of the area contaminated with PCBs greater than 25 ppm.

Calculations for area in square feet are as follows:

Area 4: 100' (width) \* 106' (length) = 10,600 square feet  
Area 3: 100' (width) \* 106' (length) = 10,600 square feet  
Area 2: 80' (width) \* 120' (length) = 9,600 square feet  
30,800 square feet  
or 3,422 square yards



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The extent of PCB contamination has been estimated using all available sediment, surface soil, shallow subsurface borings, and deep subsurface borehole sample analyses completed during the RI. Volumes have been estimated for the soils exhibiting concentrations exceeding 25 ppm total PCBs. The boundary of the cleanup area in Area 2 was developed from an extrapolation of the known, highly localized areas of contamination that exhibit PCB concentrations in excess of 25 ppm.

At the ITS site, Areas 3 and 4 plus the eastern edge of Area 2 contain PCBs in excess of 25 ppm (Figure 9-1). Based on previous findings in the shallow borings, PCB contamination (above 25 ppm) extends from the surface to two feet depth. The PCB contamination decreases dramatically with depth.

Calculations for volume in cubic feet are as follows:

Area 4:	100'(width) * 106'(length) * 2'(depth)	=	21,200 cubic feet
Area 3:	100'(width) * 106'(length) * 2'(depth)	=	21,200 cubic feet
Area 2:	80'(width) * 120'(length) * 2'(depth)	=	19,200 cubic feet
			61,600 cubic feet
			or 2,281 cubic yards*

### 9.3 CONCLUSIONS

A review of the policy guidelines set forth by the EPA leads to the following conclusions concerning a cleanup policy at the ITS site.

- The recommended action level for the cleanup of PCBs at the ITS site is 25 ppm.
- The recommended action level for TCE is 161 ppm.
- The acute, short-term exposure from TCE found in the subsurface during a work activity should not pose problems with NIOSH or ACGIH guidelines.
- Remediating the surface and shallow subsurface soils to meet the PCB recommended action level results in meeting the TCE recommended action level for those same soils.

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\*The surface area and volume of soils requiring remediation have been rounded up for presentation in the FS to account for hot spots. The area and volume requiring remediation are listed respectively in the FS as 0.75 acres and 2480 cubic yards.

- The area to be remediated consists of 3,422 square yards of contaminated soils.
- The volume of the soils to be remediated is 2,281 cubic yards.

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SECTION 10  
CONCLUSIONS

A review of the data collected and analyses performed during the Remedial Investigation (RI) supplemented with data collected previously by other agencies leads to the conclusions given in the following paragraphs.

Within a one-mile radius of the ITS site there is a mix of residential, recreational and light industrial/commercial facilities, with the latter facilities immediately adjacent to the site. The nearby residential population is estimated at 2,000, and an additional 100,000 people may be located within this area at any one time during peak recreational activities associated with the Astrodome, Astro Arena, and Astroworld.

The well inventory canvassed a one-half mile radius from the site. The total depths of these wells range from 77 feet to 844 feet. It is suspected that other wells may exist in the one-mile radius, and this possibility will be investigated in Phase II.

A total of 43 surficial soil samples, 36 shallow borehole samples, and 61 samples from deep soil boreholes and monitor wells were collected. The PCB concentrations in the samples ranged from none detected to 350 ppm. The PCB contamination was principally concentrated in the upper two feet of soils, decreasing sharply with depth, and was almost nonexistent below the upper two feet of soil. The area of contamination was limited to the empty lots behind the addresses 1403, 1415, 1417, and 1419 South Loop 610 West and extended just west of these addresses for about 80 feet.

A total of four surficial soil samples, 18 shallow boring samples, and 11 samples from deep soil boreholes and monitor wells were chosen for TCE analyses. The TCE values in these samples ranged from none detected to 2000 ppm. Values were lowest at the surface and were highest (2000 ppm) within a sample collected from the uppermost aquifer. The area of contamination was limited to the empty lots behind the 1415, 1417, and 1419 South Loop 610 West addresses.

No dioxins were detected in the three surface soil and one shallow boring samples that were chosen for analysis.

POP analyses indicated minimal concentrations of several organic compounds in soil samples. PCBs and TCE were the principal organic compounds detected at the site.

The site is located within the Beaumont Clay Formation of Pleistocene age. All lithologies consist of unconsolidated soils. The uppermost stratigraphic unit consists of clay extending from the surface to the uppermost water-bearing sand, the top of which ranges from 30 to 35 feet below ground surface. A thin, 2 to 3 foot thick layer of silty, sandy clay lies within the uppermost clay at 18 to 21 feet of depth across the eastern portion of the site.

The uppermost water-bearing sand is a light tan to white clayey sand. This unit increases in sand content, from 50% to 70%, towards the eastern end of the site. This sand was probably deposited as the result of a levee or crevasse splay from a nearby Pleistocene fluvial channel. The average thickness of this sand zone is 5 feet.

Underlying the water-bearing sand is another stiff clay which was deposited above the intermediate water-bearing zone. The intermediate water-bearing zone at 84 to 94 feet depth is a clayey sand. The results of the three rounds of water samples taken from the intermediate water-bearing zone are inconclusive due to excessive silting of the contaminated well (MW-3) located in this zone. However, a soil sample collected from this zone showed a TCE concentration of 15 ppm.

Water level measurements established a north-northwest groundwater flow in the uppermost water-bearing sand. Falling head tests indicated hydraulic conductivities ranging from 0.6 to 2 feet/day. Water from each of the six shallow monitor wells was sampled and analyzed twice for TCE. TCE concentrations ranged from 0.0035 to 430 ppm in the first round and 0.0007 to 500 ppm in the second round.

VPOP data analyses performed on water samples collected from four monitor wells, both shallow and intermediate, confirmed the presence of TCE. No other organics were detected in significant concentrations.

Seven stormwater (run-off) samples were collected and analyzed for PCBs: two from on-site, three from ditches adjacent to the site and two downstream of the site. One sample contained 0.0011 ppm PCBs, indicating the low potential for PCB migration off-site via surface run-off under the present conditions.

POP analyses were conducted on two of the stormwater samples and revealed TCE in the amount of 0.0026 ppm. No other organics were found in significant concentrations.

Six sediment samples were collected and analyzed for PCBs: four samples from ditches adjacent to the site and two from ditches downstream of the site. PCB values ranged from 0.17 to 47 ppm; however, because a background sediment sample was not successfully collected, the presence of PCBs in the ditches cannot be conclusively related to site conditions.

Air samples were also collected. No PCBs were reported on four air filters collected after the start of field sampling activities. Concentrations of total suspended particulates (TSP) ranged from 22 to 54 to 78  $\text{ug}/\text{m}^3$  upwind of the site, and from 43 to 45 to 123  $\text{ug}/\text{m}^3$  downwind of the site. The amount of particulates accumulated in the upwind and downwind filters does not provide conclusive evidence of any significant contributions of particulates from the ITS site.

PCBs have been classified by the EPA as suspected carcinogens in humans. The EPA has also concluded that PCBs are resistant to degradation, and that they bioaccumulate and bioconcentrate in the fatty tissues of organisms.

The PCBs may also be associated with mutagenicity and teratogenicity. Consistent with these findings, the EPA has reviewed TSCA policy for industrial areas with restricted access to formulate PCB cleanup criteria at the ITS site. The TSCA assessment for evaluation of PCB cleanup levels was used for determining recommended action levels because TSCA has accounted for the risks associated with exposure to PCBs in its assessments. This recommended action level for the cleanup of PCBs at the ITS site is 25 ppm.

TCE has been classified by the EPA as a probable human carcinogen. ATSDR has reviewed the risk assessments and has concluded that the 161 ppm cleanup level for TCE will provide more than enough protection for both the inhalation and ingestion exposure pathways. However, the ingestion of drinking water pathway, which may be impacted by possible TCE contamination of the groundwater, will be addressed in more detail upon completion of Phase II of the RI.

To meet the recommended action level of 25 ppm PCBs in the surface and shallow subsurface soils at the ITS site, a surface area of 3,422 square yards will require remediation. The associated volume encompassing the upper two feet of soil is 2,281 cubic yards. Meeting the 25 ppm PCBs recommended action level also results in meeting the TCE recommended action level of 161 ppm for the surface and shallow subsurface soils at the ITS site.

Groundwater and deeper subsurface contamination will be investigated in more detail in Phase II of the RI.

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**APPENDIX A-1**  
**PROPERTY DESCRIPTION**

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**Block #102 cont.**

Property Description	Account No.	Property Description	Account No.
LTS 1 & 2 BLK 101 Knight Main Street Sec 2	058 154 001 0001	S 2383 S/F of LT 4 BLK 102 Knight Main Street Sec 2	058 154 002 0004
LTS 3 & 4 BLK 101 Knight Main Street Sec 2	058 154 001 0003	LTS 5 & 6 BLK 102 Knight Main Street Sec 2	058 154 002 0005
LT 5 BLK 101 Knight Main Street Sec 2	058 154 001 0005	LT 7 BLK 102 Knight Main Street Sec 2	058 154 002 0007
S 4526 S/F of Lot 6 BLK 101 Knight Main Street	058 154 001 0006	LT 8 BLK 102 Knight Main Street Sec 2	058 154 002 0008

**Block #77**

<p>— S 4296 S/F of LT1 BLK 102 Sec 2 Knight Main Street</p>	<p>058 154 002 0001</p>	<p>Lot 1 Parts of 2,3,6 Knight Main Street BLK 77</p>	<p>055 270 077 0002</p>
<p>— S 108.54 x 74.27 x 106 x 50.83 ft. of LTS 2 &amp; 3 BLK 102 Knight Main Street. Sec 2</p>	<p>058 154 002 0002</p>	<p>LTS 5 &amp; 6, PT of LT 1 BLK 76 &amp; LT 4 &amp; 5 &amp; pt of LTS 2 &amp; 3 &amp; 6 BLK 77 .6222 Acs. Knight Main Street</p>	<p>055 270 077 0004</p>

N 106145 S/F of LTS 1 & 2 & 3 BLK 76 Knight Main Street	055 270 076 0001
S 1762 S/F of LTS 2 BLK 76 Knight Main Street	055 270 076 0002
LTS 4 & 5 2383 S/F LT 3 BLK 76 Knight Main Street	055 270 076 0003

**APPENDIX A-2**  
**FOOTNOTES FOR SITE HISTORY**

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APPENDIX A-2

FOOTNOTES FOR SITE HISTORY  
INDUSTRIAL TRANSFORMER SUPERFUND SITE

- (1) From Dalbey, F.C., Field Representative, District 7; Texas Department of Water Resources; Interoffice Memorandum; April 21, 1982.
- (2) From City of Houston Water Pollution Control Board; Investigation Report; Sol Lynn Property; September 21, 1971.
- (3) From Howard, V.N., Director, Pollution Control Division; City of Houston; written communication to Mr. Sol Lynn; January 7, 1972.
- (4) Harris County Criminal Court, December 19, 1972.
- (5) From Macko, K., Field Representative, District 7; Texas Department of Water Resources; Interoffice Memorandum; November 27, 1978.
- (6, 7) From Macko, K., Field Representative, District 7; Texas Department of Water Resources; Interoffice Memorandum; February 14, 1980.
- (8) From Dalbey, F.C., Field Representative, District 7; Texas Department of Water Resources; Investigation Report; Sol Lynn Property, September 14, 1981.
- (9) From Dalbey, F.C., Field Representative, District 7; Texas Department of Water Resources; Interoffice Memorandum; October 12, 1982.
- (10) From Nemir, C.E., Executive Director; Texas Department of Water Resources; written communications to J. Mattox, Attorney General of Texas, Austin, Texas; March 7, 1983.
- (11) From Coloton, Merton J., Supervisor, District 7; Texas Department of Water Resources; written communications to Mr. Sol Lynn; March 23, 1982.
- (12) From Lynn, S. to Dalbey, F.C., Field Representative, District 7; Texas Department of Water Resources; Telephone Memorandum to the File; March 29, 1982.
- (13) From Thompson, C.G., attorney; in written communications to Texas Department of Water Resources; April 23, 1982.
- (14) From Whittington, D., Regional Administrator; U.S. Environmental Protection Agency, Region 6, Dallas, Texas; in written communications to Mr. Sol Lynn; May 8, 1985.

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APPENDIX A-2  
(Cont'd)

- (15) From Dick, M., Head, Solid Waste Enforcement Unit; Texas Department of Water Resources; Interoffice Memorandum; February 29, 1984.
- (16) 281st Judicial District, Court of Harris County, Texas; Case No. 83-41413; Plaintiff's First Amended Original Petition.

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**APPENDIX A-3**  
**EXISTING SURFACE WATER AND GROUNDWATER DATA**

001060

**APPENDIX A-3**  
**Existing Surface Water and Groundwater Data**

SAMPLE DATE	SAMPLE COLLECTOR AND AFFILIATION	SAMPLE LAB ID.	SAMPLE RESULTS (ppb)		SAMPLE DESCRIPTION AND LOCATION	OTHER/COMMENTS
			PCB	TCF		
9-14-81	B. McDONALD DIXON - C.D.M.	S113 C.H.N.D.		953 ppb	Tap water at 1417 S. Loop West	Tetrachloroethane = 3.5 ppb Toluene = 0.03 ppb 1,2 Dichloroethylene = 0.23 ppb Dichloromethane = 0.16 ppb
9-18-81	LEN TURNICK - C.D.M.	S203 C.H.N.D.		461.5 ppb	Drinking water at 1417 S. Loop West	
		S204 C.H.N.D.		70 ppb	Drinking water at 1403 S. Loop West	
		S263 C.H.N.D.		50 ppb	Drinking water at 2032 Mansard Private well (S.M. Bell)	
11-4-81	FRED DALBEY - T.D.H.R.	03314 T.D.H.	NA	ND	Well water - well head at 1313 S. Loop West	
12-17-81	FRED DALBEY - T.D.H.R.	00624 T.D.H.	NA	ND	Ditch water - E. ditch north of 1419 S. Loop West on Mansard	Organics ND by GC/MS
12-17-81	FRED DALBEY - T.D.H.R.	00629 T.D.H.	NA	ND	Ditch water - E. ditch south of 1415 S. Loop West on Mansard	Organics ND by GC/MS
12-17-81	FRED DALBEY - T.D.H.R.	00630 T.D.H.	NA	High ppb	Tap water - bathroom tap at 1419 S. Loop West	Trichloroethylene = Toluene = Trace Trichlorobenzene = 30
03-12-82	FRED DALBEY - T.D.H.R.	01506 T.D.H.	<1	200 ppb	Tap water - bathroom tap at 1415 S. Loop West	Tetrachloroethylene = 1.5 ppb Toluene = 800 Methylene Chloride = Xylene = 300 Trichlorobenzene = 600
04-12-82	SOL LYNN - PROPERTY OWNER		NA	101.40 ppb	Water sample at 1417 S. Loop West	Reported via telephone memo
09-15-82	FRED DALBEY - T.D.H.R.	01913 T.D.H.	NA	ND	Tap water - tap at 1403 S. Loop West	Volatile organics ND by GC/MS
12-03-82	FRED DALBEY - T.D.H.R.	02161 T.D.H.	NA	237 ppb	Well water - bottom of well at 1419 S. Loop West	t-1,2 dichloroethylene = 800 Tetrachloroethylene = Toluene = 600 1,1 dichloroethylene = 100

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**APPENDIX A-3**  
**Existing Surface Water and Groundwater Data**  
**(Continued)**

SAMPLE DATE	SAMPLE COLLECTION AND AFFILIATION	SAMPLE LAB ID.	SAMPLE RESULTS (ppb)		SAMPLE DESCRIPTION AND LOCATION	OTHER/COMMENTS
			PCB	TCE		
04-12-83	FRED DALBEY - T.B.H.R.	05601 T.B.H.	NA	NA	Well water - well head at 1419 S. Loop West	Ar = 12, Cd = 31, Pb = 190, Ni = 20, Zn = 8300, Ba = 4500, Cr = 420, Mn = 390, Se = 40, Cu = 440
04-18-84	GAIL CORRIGAN - T.B.H.R.	03435 T.B.H.	NA	ND	Tap water - tap in building at 1403 S. Loop West	
01-16-84	MICHAEL WARNER - ROY F. WESTON	4-09691 A.P.R.	NA	1.2	Tap water - tap at 1417 S. Loop West	PURGEABLE PRIORITY POLLUTANTS: Dichloroethylene = 13 Chloroform = 17.3 Bromodichloromethane = 2.3
01-16-84	MICHAEL WARNER - ROY F. WESTON	4-09695 A.P.R.	ND	ND	Surface water - puddle of water on site	PURGEABLE PRIORITY POLLUTANTS: ND
		16917 A.P.R.	ND	NA	Surface water - water standing on site	
03-06-85	SOL LYNN - PROPERTY OWNER	07 CHAS. V. BACON	<1 ppb	NA	Well water	
03-26-85	SOL LYNN - PROPERTY OWNER	0531306 CHROMA SPEC	NA	<1 ppb	Well water - S.W. Bell well on Mansard St.	
05-07-85	SOL LYNN - PROPERTY OWNER	03 S & B LAB	NA	2	Water at 1403 S. Loop West Con Equip.	By Purge and Trap Method
		17 S & B LAB	NA	3	Water at 1419 S. Loop West Sol Lynn	By Purge and Trap Method
05-24-85	SOL LYNN - PROPERTY OWNER	0551344 CHROMA SPEC	NA	<1.0 ppb	Well water - well at rear of bldg. at 1419 S. Loop West	Volatile organics ND by GC/MS
06-07-85	SUSAN SIEGAL - E.P.A.	AV0201 E.P.A.	NA	ND	Well water	Acetone = 3.8 Chloroform = 5.06 Methylene Chloride = 18.2
06-07-85	SUSAN SIEGAL - E.P.A.	0560336	NA	ND	Well water - well behind bldg. at 1419 S. Loop West	Volatile Organics ND by GC/MS

APR - Analytical Petroleum Research  
CHMD - City of Houston Health Department  
CHN - City of Houston  
EPA - Environmental Protection Agency  
NA - Not Analyzed  
ND - Not Detected  
TDH - Texas Department of Health  
TDMR - Texas Department of Motor Resources  
TQSD - Texas Water Quality Board

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**APPENDIX A-4**  
**EXISTING SOIL ANALYSIS DATA**

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**APPENDIX A-4**  
Existing Soil Analysis Data

SAMPLE DATE	SAMPLE COLLECTOR AND AFFILIATION	SAMPLE LAB ID.	SAMPLE RESULTS (ppb)		OTHER/COMMENTS
			PCB	TCE	
9-11-01	PAUL PINTO - C.D.N.	C.N.H.D.	NA	POSITIVE	Positive for 1,2 Dichloroethylene, Dichloromethane, Tetrachloroethane, Toluene & 1,1 Dichloroethylene
9-21-01	LEN TURNOCK - C.D.N.	5205 C.N.H.D.	NA	<1	
		5206 C.N.H.D.	NA	<1	
		5207 C.N.H.D.	NA	370	
9-23-01	LEN TURNOCK - C.D.N.	5334 C.N.H.D.	NA	1719 ppb	
		5333 C.N.H.D.	NA	737 ppb	
		5335 C.N.H.D.	NA	154 ppb	
11-30-01	LEN TURNOCK - C.D.N.	6560 C.N.H.D.	390.2	23.0	
		6561 C.N.H.D.	42.3	41.0	
		6562 C.N.H.D.	21.3	19.9	
		6563 C.N.H.D.	1.7 ppb	1.0 ppb	
		6564 C.N.H.D.	2.37 ppb	7.64 ppb	
		6565 C.N.H.D.	2.26 ppb	2062.3 ppb	
		6566 C.N.H.D.	3.92 ppb	1.24 ppb	
		6567 C.N.H.D.	729.6	409.7	
		6568 C.N.H.D.	405.3	217.7 ppb	
		6569 C.N.H.D.	3.66 ppb	14.0 ppb	
		6570 C.N.H.D.	14.9	14.0	
		6571 C.N.H.D.	351.9	49.9	

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PEN A-4  
Existing Soil Analysis Data  
(Continued)

SAMPLE DATE	SAMPLE COLLECTOR AND AFFILIATION	SAMPLE LAB ID.	SAMPLE RESULTS (ppb)		OTHER/COMMENTS
			PCB	TCE	
12-17-81	FRED DALBEY - T.D.N.R.	00628 T.D.N.	NA	ND	ORGANICS ND BY GC/MS
		00631 T.D.N.	NA	ND	ORGANICS ND BY GC/MS
		00632 T.D.N.	NA	ND	ORGANICS ND BY GC/MS
3-12-82	FRED DALBEY - T.D.N.R.	01515 T.D.N.	24.7 ppb	NA	
		01516 T.D.N.	22.3 ppb	NA	
4-12-82	GOL LYNN - PROPERTY OWNER		NA	1.45 ppb	REPORTED VIA TELEPHONE MEMO
4-16-82	FRED DALBEY - T.D.N.R.	01593 T.D.N.	10.74 ppb	300 ppb	
		01594 T.D.N.	57.0 ppb	20 ppb	
		01595 T.D.N.	41.3 ppb	350 ppb	
4-12-83	FRED DALBEY - T.D.N.R.	04653 T.D.N.	10 ppb	ND	
		04655 T.D.N.	5.4 ppb	325 ppb	t-1,2 dichloroethylene = 44 ppb Tetrachloroethylene = 16 ppb Toluene = 8 ppb
		04656 T.D.N.	15 ppb	<0.5 ppb	Pb = 34 ppb, Cr = 26 ppb, As = 4.1 ppb Cd = <0.4 ppb, Zn = 88 ppb, Se = 0.9 ppb
		04657 T.D.N.	0.13 ppb	NA	
		04658 T.D.N.	12.3 ppb	NA	
12-12-83	GAIL CORRIGAN - T.D.N.R.	04367 T.D.N.	99 ppb	Trace	Volatile organics ND by GC/MS
		04368 T.D.N.	3.7 ppb	216 ppb	Volatile organics ND by GC/MS

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APPENDIX A-4  
Existing Soil Analysis Data  
(Continued)

SAMPLE DATE	SAMPLE COLLECTOR AND AFFILIATION	SAMPLE LAB ID.	SAMPLE RESULTS (ppb)		OTHER/COMMENTS
			PCB	TCE	
1-26-84	GAIL CORRIGAN - T.D.N.R.	03305 T.D.N.	14.4 ppb	ND	Volatile organics ND by GC/MS
		03306 T.D.N.	34.8 ppb	ND	Volatile organics ND by GC/MS
4-18-84	GAIL CORRIGAN - T.D.N.R.	03436 T.D.N.	ND	ND	
1-16-84	MICHAEL WARNER - ROY F. WESTON	6-09905 A.P.R.	29 ppb	ND	
		6-09906 A.P.R.	ND	3 ppb	
		6-09907 A.P.R.	14 ppb	ND	
		6-09908 A.P.R.	7 ppb	ND	
		1694	8 ppb	ND	
		6-09910 A.P.R.	20 ppb	ND	
		6-09872 A.P.R.	9 ppb	ND	
		6-09873 A.P.R.	ND	ND	
		6-09694 A.P.R.	NA	8.4	Purgeable priority pollutants Dichloroethylene = 169.7
		6-09700 A.P.R.	ND	NA	
		6-09874 A.P.R.	ND	ND	
		6-09699 A.P.R.	ND	67.4	Purgeable priority pollutants Ethylene = 227.8 Benzene = 0.2
		16919 A.P.R.	ND	NA	
		6-09697 A.P.R.	ND	ND	
		6-09698 A.P.R.	ND	ND	
		6-09696 A.P.R.	ND	9 ppb	

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APPENDIX A -  
Existing Soil Analysis Data  
(Continued)

SAMPLE DATE	SAMPLE COLLECTOR AND AFFILIATION	SAMPLE LAB ID.	SAMPLE RESULTS (ppb)		OTHER/COMMENTS
			PCB	TCE	
2-26-85	SUBAN FERGUSON - T.D.W.R.	06690 T.D.H.	71.6 ppb	ND	
		06697 T.D.H.	18.6 ppb	ND	
		06699 T.D.H.	0.536 ppb	ND	
3-6-85	SOL LYNN - PROPERTY OWNER	01 CHAS. V. BACON	3 ppb	0.07 ppb	
		02 " " "	17 ppb	0.04 ppb	
		03 " " "	15 ppb	NA	
		04 " " "	12 ppb	NA	
		05 " " "	9 ppb	NA	
		06 " " "	0.5 ppb	NA	
3-26-85	SOL LYNN - PROPERTY OWNER	0531304 CHROMA SPEC	12 ppb	NA	
		0531305 CHROMA SPEC	32 ppb	NA	
		0531309 CHROMA SPEC	<1 ppb	NA	
		0540136 CHROMA SPEC	NA	<1	

APR - Analytical Petroleum Research  
CHHD - City of Houston Health Department  
CDH - City of Houston  
NA - Not Analyzed  
ND - Not Detected  
TDH - Texas Department of Health  
TDWR - Texas Department of Water Resources

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**APPENDIX B-1**  
**PHYSICAL AND CHEMICAL CHARACTERISTICS**  
**OF LAKE CHARLES SOIL**

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**PHYSICAL AND CHEMICAL CHARACTERISTICS  
OF LAKE CHARLES SOIL\***

<u>Depth</u>	<u>USDA Texture</u>	<u>Classification</u>		<u>Percentage passing sieve number</u>				<u>Liquid Limit</u>	<u>Plasticity Index</u>
		<u>Unified</u>	<u>AASHTO</u>	<u>4</u>	<u>10</u>	<u>40</u>	<u>200</u>		
0-22in.	Clay	CH	7	100	99-100	80-100	75-100	64-80	40-55
22-74in.	Clay	CH	7	98-100	98-100	80-100	75-100	54-90	37-60

<u>Depth</u>	<u>Permeability</u>	<u>Available Water Capacity</u>	<u>Soil Reaction</u>	<u>Shrink-Swell Potential</u>	<u>Risk of Corrosion</u>		<u>Erosion Factors</u>	
					<u>uncoated steel</u>	<u>concrete</u>	<u>K</u>	<u>T</u>
0-22in.	0.06 -0.2	0.15 - 0.20	6.1 - 7.8	High	High	Low	0.32	5
22-74in.	<0.06	0.15 - 0.20	6.6 - 8.4	High	High	Low	0.32	

\* Soil Survey of Harris County, Texas, 1976.

001069

## Explanation of Parameters

USDA Texture - U.S. Department of Agriculture uses standard terms to describe texture. These terms are defined according to percentages of sand, silt and clay material that is less than 2 mm in diameter. Specifically, grain-size distribution, plasticity index, liquid limit, and organic matter content are examined. "CH" indicates a fine grained class.

Classification: Unified - Classifies soil according to properties that affect their use as construction material. ASSHTO (American Association of State Highway and Transportation Officials) - Classifies soils according to properties that affect use of the soils in highway construction and maintenance. There are 7 groups, based on grain-size distribution, liquid limit and plasticity index. Soils classified as A-7 are fine-grained.

Percentage passing sieve number - Sand and other granular material are retained on a No. 200 sieve but finer particles pass through it. Clay is a fraction smaller than 0.002 mm in diameter. Silt is intermediate in size between having the material held on the No. 200 sieve and that having a diameter of 0.002 millimeter.

Liquid Limit and Plasticity Index - These parameters indicate the effect water has on the strength and consistency of soil material. As the moisture content of a dry clayey soil is increased, the soil material changes from solid to plastic. If the moisture content is further increased, the material changes from plastic to liquid. The plastic limit is the moisture content at which the material changes from solid to plastic. The liquid limit is the moisture content at which the material changes from plastic to liquid. The plasticity index is the numerical difference between the liquid limit and the plastic limit. It indicates the range of moisture content within which a soil is plastic.

Permeability - Estimated on the basis of known relationships between soil characteristics observed in the field - such as soil structure, porosity and gradation or texture - that influence the downward movement of water in a saturated soil.

Available Water Capacity - Certain soil characteristics such as content of organic matter, soil texture and soil structure, influence the ability of the soil to hold water and make it available to plants.

Soil Reaction - Usually expressed as a range in pH values.

Shrink-Swell Potential - This depends mainly on the amount and kind of clay in the soil. A high shrink - swell potential indicates that special design and added expense may be required if the planned use of the soil will not tolerate large volume changes.

001070

Risk of Corrosion - Pertains to potential soil-induced chemical action that dissolves or weakens uncoated steel or concrete. The rate of corrosion of uncoated steel is related to soil moisture, particle - size distribution, total acidity and electrical conductivity of the soil. The rating of soils for corrosivity to concrete is based mainly on the sulfate content, soil texture, and acidity.

Erosion Factors - Used to predict the amount of erosion resulting from specific kinds of land treatment. K is a soil erodability factor that measures the susceptibility of the soil to erosion by water. Soils having the highest K values are the most erodible. The soil-loss tolerance factor (T) is the maximum rate of soil erosion, whether from rainfall or wind, that may occur without reducing crop production or environmental quality.

\* Soil Survey of Harris County, Texas

001071



**APPENDIX B-2**  
**CITY OF HOUSTON WATER QUALITY**

001072



# CITY OF HOUSTON

Post Office Box 1562 Houston, Texas 77251

Kathryn J. Whitmire, Mayor

CITY COUNCIL MEMBERS: Larry McKaskle • Ernest McGowen, Sr. • George Greer • Rodney Ellis • Frank O. Mancuso • John G. Goodner • Christin Hartung  
Jale M. Gorkzynski • Ben T. Reyes • Jim Westmoreland • Eleanor Tinsley • Jim Greenwood • Anthony W. Hall, Jr. • Judson Robinson, Jr. • CITY CONTROLLER: Lance Lalor

August 17, 1987

Mr. Ahmed Raez  
Radin Corporation  
10675 Richmond Ave.  
Houston, Texas 77042

Dear Mr. Raez:

Please find attached a copy of the most recent analysis of the Surface Water Plant. This plant is servicing the area you had requested information on.

Recent organic analyses of this water included volatile organics, semi-volatile organics, herbicides, and pesticides, and all were below detection limits.

If you have any questions or require further information, please do not hesitate to call our office at 880-2444.

Sincerely,

A handwritten signature in black ink, appearing to read "A. LaFargue".

Aubrey A. LaFargue  
Manager  
Water Quality Control Branch  
Department of Public Works

AAL:jsc  
Attachment

001073

**CITY OF HOUSTON  
WATER QUALITY CONTROL BRANCH  
LABORATORY SECTION  
WATER ANALYSIS REPORT**

Laboratory No. 288-7

Sample Source                      Distribution                      Location                      Laboratory Sample Tap                     

Date Submitted 7/13/87 Date Analyzed 7/13/87 Sampled By IM

		<u>P.P.M.</u>	<u>G.P.G.</u>
Silica	SiO <sub>2</sub> .....	5.8	0.34
Calcium	Ca.....	26	1.52
Magnesium	Mg.....	2.32	0.14
Sodium	Na.....	29.11	1.70
Potassium	K.....	2.95	0.17
Sulfate	SO <sub>4</sub> .....	44	2.57
Chloride	Cl.....	25	1.46
Carbonate	CO <sub>3</sub> .....	2	0.12
Bicarbonate	HCO <sub>3</sub> .....	68	3.97
Nitrate	NO <sub>3</sub> .....	0.28	0.02
Phosphate	PO <sub>4</sub> .....	0.2	0.01
Total Dissolved Solids.....		205.66	12.01
Suspended Solids.....		0.8	
Specific Conductance (umhos/cm).....		300	
Total Alkalinity (CaCO <sub>3</sub> ).....		58	
Hardness (as CaCO <sub>3</sub> ).....		80	4.67
Turbidity (NTU).....		0.11	
Fluoride (F).....		0.77	
Color (platinum-cobalt units).....		4	
Total Iron.....		0.02	
Manganese (Mn).....		0.03	
Total Organic Carbon.....		9.61	
BOD (5 day).....		NR	
Dissolved Oxygen.....		NR	
pH.....		8.53	
Temperature (°F).....		82	
Odor.....		Faint Chlorine	
Chlorine Residual.....		2.3	
pH <sub>5</sub> .....		8.19	
Langelier Index.....		0.34	

**Remarks:**

cc: Ms. Teresa Battenfield  
Mr. Warren Butler  
Mr. C.J. Lucas  
Mr. Thomas E. Bailey  
Mr. Bill Healer  
Mr. W.J. Molbert  
Mr. Curt Cranmer

*IM* IM WCH (AD)  
Analyzed By

*[Signature]*  
Chief Chemist

*G. La Farge*  
Branch Manager

001074

**APPENDIX B-3  
DISCHARGE AND WATER QUALITY DATA  
(1984 AND 1985) FOR BRAYS BAYOU**

001075



# United States Department of the Interior

GEOLOGICAL SURVEY

WATER RESOURCES DIVISION  
2320 La Branch St., Rm. 1112  
HOUSTON, TEXAS 77004

August 18, 1987

Riaz Ahmed  
Radin Corporation  
10675 Richmond Ave.  
Houston, TX 77042

Dear Sir:

Enclosed are copies of discharge and water-quality sheets for the stations listed below, covering the periods shown:

Station No. and Name

	<u>From</u>	<u>To</u>
08075500 Sims Bayou at Houston, TX	10/01/83	9/30/86
08075000 Brays Bayou at Houston, TX	10/01/83	9/30/86

Sincerely,

*James C. Fisher*  
James C. Fisher  
Supervisory Hydrologist  
Houston Subdistrict, WRD

RDL/bdp  
Enclosures

001076

## 08075000 BRAYS BAYOU AT HOUSTON, TX

LOCATION.--Lat 29°41'49", long 95°24'43", Harris County, Hydrologic Unit 12040104, near right bank at downstream side of Main Street Bridge in southwest Houston, 1.6 mi upstream from Harris Gully, and 11.6 mi upstream from Buffalo Bayou.

DRAINAGE AREA.--94.9 mi<sup>2</sup>. Prior to October 1976, 88.4 mi<sup>2</sup>. Changes due to drainage ditch relocations.

## WATER-DISCHARGE RECORDS

PERIOD OF RECORD.--May 1936 to current year.

REVISED RECORDS.--WSP 1732: Drainage area.

GAGE.--Water-stage recorder. Datum of gage is 7.16 ft below National Geodetic Vertical Datum of 1929, 1973 adjustment; unadjusted for land-surface subsidence. Prior to June 20, 1936, nonrecording gage, and June 20, 1936, to Nov. 23, 1959, water-stage recorder at site 0.8 mi downstream at same datum.

REMARKS.--Water-discharge records fair except those for period of no gage-height record and those below 200 ft<sup>3</sup>/s, which are poor. No diversion above station. Low flow is mostly sewage effluent from Houston suburbs.

AVERAGE DISCHARGE.--48 years, 126 ft<sup>3</sup>/s (91,290 acre-ft/yr).

EXTREMES FOR PERIOD OF RECORD.--Maximum discharge, 29,000 ft<sup>3</sup>/s June 15, 1976, and Sept. 19, 1983 (gage height, 52.13 ft); minimum daily, 0.1 ft<sup>3</sup>/s Oct. 11, 12, 1937, Mar. 14, Apr. 1, 1958.

EXTREMES OUTSIDE PERIOD OF RECORD.--Maximum stage since 1911, 56.0 ft in June 1919 before channel rectification, former site, from information by engineer for city of Houston.

EXTREMES FOR CURRENT YEAR.--Peak discharges above base of 6,000 ft<sup>3</sup>/s and maximum (\*):

Date	Time	Discharge (ft <sup>3</sup> /s)	Gage height (ft)
Nov. 30	unknown	*8,640	438.31
Jan. 9	0545	8,540	38.21

a From peak mark.

Minimum daily discharge, 94 ft<sup>3</sup>/s Nov. 26.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1983 TO SEPTEMBER 1984  
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	119	180	400	125	120	115	95	110	110	160	114	161
2	118	118	150	125	160	118	220	110	110	166	162	702
3	123	115	350	120	200	110	120	105	105	173	224	203
4	121	114	150	110	120	110	100	105	105	127	281	167
5	120	209	120	100	110	170	95	110	120	123	427	154
6	114	817	110	100	130	120	95	110	1050	179	172	130
7	114	219	105	105	110	100	100	160	334	118	142	225
8	113	121	105	117	100	110	200	130	135	110	126	120
9	114	162	100	2670	600	100	150	110	99	147	202	112
10	119	129	135	352	200	110	110	100	103	138	186	117
11	119	108	150	172	150	120	100	100	106	128	350	114
12	117	112	120	139	500	240	105	100	120	126	240	130
13	111	104	100	124	200	326	110	100	110	114	190	126
14	112	111	100	119	150	120	110	100	105	110	190	116
15	108	104	95	139	140	110	130	100	100	179	140	229
16	143	97	600	127	130	105	120	100	100	132	120	224
17	331	100	200	116	130	100	115	140	100	120	115	135
18	127	98	130	117	125	100	110	520	95	473	120	120
19	120	139	125	115	130	532	105	1330	100	489	110	116
20	109	109	120	113	530	148	105	460	95	148	115	121
21	116	101	170	110	350	116	105	200	99	124	110	703
22	113	115	120	110	200	111	100	130	103	120	110	462
23	111	246	100	900	150	234	105	110	95	245	115	164
24	114	111	95	400	130	400	110	105	96	688	180	146
25	108	95	95	200	130	180	100	105	99	372	180	149
26	102	94	110	150	370	140	105	100	108	172	150	121
27	98	157	150	140	150	120	105	100	105	145	130	118
28	107	115	135	130	118	110	100	105	105	251	119	108
29	101	100	120	130	115	105	100	120	106	168	115	107
30	102	2000	110	200	---	100	120	110	121	119	113	106
31	177	---	110	140	---	95	---	110	---	112	116	---
TOTAL	3821	6400	4780	7815	5748	4775	3445	5495	4339	5976	5164	5706
MEAN	123	213	154	252	198	154	115	177	145	193	167	190
MAX	331	2000	600	2670	600	532	220	1330	1050	688	427	703
MIN	98	94	95	100	100	95	95	100	95	110	110	106
AC-FT	7580	12690	9480	15500	11400	9470	6830	10900	8610	11850	10240	11320
CAL YR 1983 TOTAL	122001		MEAN 334	MAX 12900	MIN 94	AC-FT 242000						
WTR YR 1984 TOTAL	63464		MEAN 173	MAX 2670	MIN 94	AC-FT 125900						

NOTE.--No gage-height record Nov. 30 to Jan. 5 and many other shorter periods.

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HOUSTON RIVER BASIN  
03075003 BRAYS BAYOU AT HOUSTON, TX--Continued

## WATER-QUALITY RECORDS

PERIOD OF RECORD.--Chemical, biochemical, and pesticide analyses: October 1968 to current year.

## WATER QUALITY DATA, WATER YEAR OCTOBER 1983 TO SEPTEMBER 1984

DATE	TIME	STREAM- FLOW, INSTAN- TANEOUS (CFS)	SPE- CIFIC CON- DUCT- ANCE (UMHOS)	PH (STAND- ARD UNITS)	TEMPER- ATURE (DEG C)	COLOR (PLAT- INUM- COBALT UNITS)	TUR- BID- ITY (NTU)	OXYGEN, DIS- SOLVED (MG/L)	OXYGEN, DIS- SOLVED (PER- CENT SATUR- ATION)	OXYGEN DEMAND, BIO- CHEM- ICAL, 5 DAY (MG/L)	COLI- FORM, FECAL, 0.7 UM-MF (COLS./ 100 ML)	STREP- TOCOCCI FECAL, KF AGAR (COLS. PER 100 ML)
FEB 07...	1430	113	832	7.8	19.0	5	6.7	13.8	147	6.5	80	K2
MAR 23...	2147	444	513	7.4	20.5	280	40	4.4	49	17	96000	46000
23...	2320	1700	211	7.2	20.5	560	52	4.5	50	15	74000	210000
24...	0105	1110	222	7.2	17.5	280	100	5.8	61	14	44000	160000
24...	1150	291	450	7.7	19.5	280	72	7.8	85	6.9	14000	K100000
JUL 02...	1010	170	601	8.0	28.0	50	33	7.9	99	6.5	K3	K18
AUG 06...	0930	103	595	7.6	27.5	40	15	9.4	117	5.1	36	30

DATE	HARD- NESS (MG/L AS CAC03)	HARD- NESS, NONCAR- BONATE (MG/L CAC03)	CALCIUM DIS- SOLVED (MG/L AS CA)	MAGNE- SIUM, DIS- SOLVED (MG/L AS MG)	SODIUM, DIS- SOLVED (MG/L AS NA)	SODIUM AD- SORP- TION RATIO	POTAS- SIUM, DIS- SOLVED (MG/L AS K)	ALKA- LITY FIELD (MG/L CAC03)	SULFATE DIS- SOLVED (MG/L AS SO4)	CHLO- RIDE, DIS- SOLVED (MG/L AS CL)	FLUO- RIDE, DIS- SOLVED (MG/L AS F)	SILICA, DIS- SOLVED (MG/L AS SiO2)
FEB 07...	170	0	50	11	110	4	6.4	230	43	86	.50	22
MAR 23...	110	0	32	6.7	61	3	5.1	130	32	53	.40	12
23...	--	--	--	--	--	--	--	--	--	--	--	--
24...	54	0	17	2.8	20	1	3.6	59	17	16	.20	5.5
24...	--	--	--	--	--	--	--	--	--	--	--	--
JUL 02...	120	0	38	7.1	77	3	5.9	130	36	65	.40	18
AUG 06...	140	0	43	8.2	69	3	5.6	160	32	58	.40	18

DATE	SOLIDS, SUM OF CONSTIT- UENTS, DIS- SOLVED (MG/L)	SOLIDS, RESIDUE AT 105 DEG. C, SUS- PENDED (MG/L)	SOLIDS, VOLATILE, SUS- PENDED (MG/L)	NITRO- GEN, NITRATE TOTAL (MG/L AS N)	NITRO- GEN, NITRITE TOTAL (MG/L AS N)	NITRO- GEN, NO2+NO3 TOTAL (MG/L AS N)	NITRO- GEN, AMMONIA TOTAL (MG/L AS N)	NITRO- GEN, ORGANIC TOTAL (MG/L AS N)	NITRO- GEN,AM- MONIA + ORGANIC TOTAL (MG/L AS N)	PHOS- PHORUS, TOTAL (MG/L AS P)	CARBON, ORGANIC TOTAL (MG/L AS C)
FEB 07...	470	<2	<2	3.2	.820	4.0	2.90	2.1	5.0	4.10	8.7
MAR 23...	280	149	45	1.6	.360	2.0	.360	4.6	5.0	3.00	18
23...	--	206	46	.91	.090	1.0	1.10	1.6	2.7	1.00	21
24...	120	208	49	1.2	.210	1.4	1.40	1.8	3.2	2.70	17
24...	--	86	27	2.0	.160	2.2	1.10	1.5	2.6	2.10	14
JUL 02...	330	64	19	2.7	.260	3.0	.760	1.3	2.1	2.20	10
AUG 06...	330	25	7	3.0	.340	3.3	.730	1.1	1.8	3.30	7.7

DATE	TIME	ARSENIC DIS- SOLVED (UG/L AS AS)	BARIUM, DIS- SOLVED (UG/L AS BA)	CADMIUM DIS- SOLVED (UG/L AS CD)	CHRO- MIUM, DIS- SOLVED (UG/L AS CR)	COPPER, DIS- SOLVED (UG/L AS CU)	IRON, DIS- SOLVED (UG/L AS FE)
JUL 02...	1010	8	130	<1	<10	5	11
AUG 06...	0930	20	120	<1	<10	5	12

DATE	LEAD, DIS- SOLVED (UG/L AS PB)	MANGA- NESE, DIS- SOLVED (UG/L AS MN)	MERCURY DIS- SOLVED (UG/L AS HG)	SELE- NIUM, DIS- SOLVED (UG/L AS SE)	SILVER, DIS- SOLVED (UG/L AS AG)	ZINC, DIS- SOLVED (UG/L AS ZN)
JUL 02...	<1	9	<.1	<1	<1	20
AUG 06...	<1	2	<.1	<1	<1	7

001078

SAN LACINTO RIVER BASIN  
08075000 BRAYS BAYOU AT HOUSTON, TX--Continued

WATER QUALITY DATA, WATER YEAR OCTOBER 1983 TO SEPTEMBER 1984

DATE	TIME	AME- TRYNE TOTAL	ATRA- ZINE, TOTAL (UG/L)	CYAN- AZINE TOTAL (UG/L)	METHO- MYL TOTAL (UG/L)	PROME- TONE TOTAL (UG/L)	PROME- TRYNE TOTAL (UG/L)	PRO- PAZINE TOTAL (UG/L)	PROPHAM TOTAL (UG/L)	SEVIN, TOTAL (UG/L)	SIMA- ZINE TOTAL (UG/L)	SIME- TRYNE TOTAL (UG/L)
JUL 02...	1010	<.10	<.10	<.10	<2.0	.1	<.1	<.10	<2.0	<2.0	<.10	<.1
AUG 06...	0930	<.10	.50	<.10	<2.0	.4	<.1	<.10	<2.0	<2.0	.20	<.1

001079



SAN JACINTO RIVER BASIN  
08075000 BRAYS BAYOU AT HOUSTON, TX

LOCATION.--Lat 29°41'49", long 95°24'43", Harris County, Hydrologic Unit 12040104, near right bank at downstream side of Main Street Bridge in southwest Houston, 1.6 mi upstream from Harris Gully, and 11.6 mi upstream from Buffalo Bayou.

DRAINAGE AREA.--94.9 mi<sup>2</sup>. Prior to October 1976, 88.4 mi<sup>2</sup>. Changes due to drainage ditch relocations.

WATER-DISCHARGE RECORDS

PERIOD OF RECORD.--May 1936 to current year.

REVISED RECORDS.--WSP 1732: Drainage area.

GAGE.--Water-stage recorder. Datum of gage is 7.16 ft below National Geodetic Vertical Datum of 1929, 1973 adjustment; unadjusted for land-surface subsidence. Prior to June 20, 1936, nonrecording gage, and June 20, 1936, to Nov. 25, 1959, water-stage recorder at site 0.8 mi downstream at same datum.

REMARKS.--Estimated daily discharge: July 2-12. Records good. No diversion above station. Low flow is mostly sewage effluent from Houston suburbs. Gage-height telemeter at station.

AVERAGE DISCHARGE.--49 years, 128 ft<sup>3</sup>/s (92,740 acre-ft/yr).

EXTREMES FOR PERIOD OF RECORD.--Maximum discharge, 29,000 ft<sup>3</sup>/s June 15, 1976, and Sept. 19, 1983 (gage height, 52.13 ft); minimum daily, 0.1 ft<sup>3</sup>/s Oct. 11, 12, 1937, Mar. 14, Apr. 1, 1958.

EXTREMES OUTSIDE PERIOD OF RECORD.--Maximum stage since 1911, 56.0 ft in June 1919 before channel rectification, former site, from information by engineer for city of Houston.

EXTREMES FOR CURRENT YEAR.--Peak discharges greater than base discharge of 6,000 ft<sup>3</sup>/s and maximum (\*):

Date	Time	Discharge (ft <sup>3</sup> /s)	Gage height (ft)	Date	Time	Discharge (ft <sup>3</sup> /s)	Gage height (ft)
Oct. 14	0730	6,900	36.58	Mar. 14	1100	9,670	39.26
Oct. 25	1645	7,380	37.07	Mar. 20	0800	*13,200	*42.22
Feb. 23	1145	6,200	35.84	Apr. 13	2145	6,770	36.45

Minimum daily discharge, 93 ft<sup>3</sup>/s Nov. 24.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1984 TO SEPTEMBER 1985  
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	108	137	95	412	117	729	125	108	103	103	119	123
2	108	1380	132	601	122	239	117	101	100	110	169	119
3	102	213	102	561	119	179	116	99	103	280	641	120
4	109	145	362	225	150	189	114	99	105	390	183	127
5	126	123	431	161	126	142	112	102	106	140	171	168
6	221	113	150	140	116	125	108	102	106	120	127	135
7	114	115	108	133	118	125	107	101	104	113	120	125
8	117	115	109	129	115	125	109	113	102	110	121	126
9	338	110	114	123	112	121	107	132	99	108	121	172
10	211	110	114	125	1080	121	108	108	118	107	119	280
11	119	106	106	112	755	121	118	104	187	106	115	165
12	115	106	103	227	178	115	129	101	622	105	120	144
13	598	104	99	187	138	114	978	160	143	112	123	143
14	1900	101	100	243	122	3540	574	131	114	185	149	130
15	286	108	99	141	114	700	129	128	105	179	126	136
16	140	168	663	500	113	491	116	111	104	127	119	133
17	409	154	172	381	112	235	110	152	106	116	120	130
18	186	394	118	164	113	171	106	126	983	124	118	127
19	1470	186	108	138	113	148	109	112	696	171	123	129
20	298	117	103	127	109	4200	294	109	259	132	786	126
21	618	110	101	126	106	559	249	318	433	119	394	119
22	387	99	103	129	106	225	126	144	185	119	150	119
23	972	101	100	123	1690	167	113	111	149	116	145	134
24	780	93	104	121	711	148	105	107	125	114	661	141
25	3990	101	101	118	795	142	104	105	113	114	359	121
26	1470	106	98	117	240	132	370	97	111	116	142	172
27	338	193	100	272	394	144	151	96	114	109	131	130
28	196	110	102	150	715	130	111	101	113	108	128	127
29	150	97	104	119	---	124	107	101	102	119	185	1110
30	133	100	1010	111	---	181	101	103	100	140	238	1170
31	129	---	1460	110	---	149	---	107	---	127	159	---
TOTAL	16238	5217	6771	6326	8799	14031	5323	3689	5910	4239	6484	6201
MEAN	524	174	218	204	314	453	177	119	197	137	209	207
MAX	3950	1380	1460	601	1690	4200	978	318	983	390	786	1170
MIN	100	93	95	110	106	114	101	96	99	103	115	119
AC-FT	32210	10350	13430	12550	17450	27830	10560	7320	11720	8410	12860	12300

CAL YR 1984 TOTAL 76689 MEAN 210 MAX 3990 MIN 93 AC-FT 152100  
WTR YR 1985 TOTAL 89226 MEAN 244 MAX 4200 MIN 92 AC-FT 177000

SAN JACINTO RIVER BASIN

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04075000 BRAYS BAYOU AT HOUSTON, TX--Continued

WATER-QUALITY RECORDS

PERIOD OF RECORD.--Chemical, biochemical, and pesticide analyses: October 1984 to current year.

WATER QUALITY DATA, WATER YEAR OCTOBER 1984 TO SEPTEMBER 1985

DATE	TIME	STREAM- FLOW, INSTAN- TANEOUS (CFS)	SPE- CIFIC CON- DUCT- ANCE (US/CM)	PH (STAND- ARD UNITS)	TEMPER- ATURE (DEG C)	COLOR (PLAT- INUM- COBALT UNITS)	TUR- BID- ITY (NTU)	OXYGEN, DIS- SOLVED (MG/L)	OXYGEN, DIS- SOLVED (PER- CENT SATUR- ATION)	OXYGEN DEMAND, BIO- CHEM- ICAL, 5 DAY (MG/L)	COLI- FORM, FECAL, 0.7 MP-MF (COLS./ 100 ML)	STREP- TOCOCCI, FECAL, KF AGAR (COLS. PER 100 ML)	
JUN 10...	1300	111	810	8.1	29.0	10	7.5	10.4	135	4.1	K2	K8	
DATE	TIME	HARD- NESS (MG/L AS CACO3)	HARD- NESS, NONCAR- BONATE (MG/L CACO3)	CALCIUM DIS- SOLVED (MG/L AS CA)	MAGNE- SIUM, DIS- SOLVED (MG/L AS MG)	SODIUM, DIS- SOLVED (MG/L AS NA)	SODIUM AD- SORP- TION RATIO	POTAS- SIUM, DIS- SOLVED (MG/L AS K)	ALKA- LINITY FIELD (MG/L AS CACO3)	SULFATE DIS- SOLVED (MG/L AS SO4)	CHLO- RIDE, DIS- SOLVED (MG/L AS CL)	FLUO- RIDE, DIS- SOLVED (MG/L AS F)	SILICA, DIS- SOLVED (MG/L AS SiO2)
JUN 10...	150	0	46	8.8	110	4	6.2	231	40	84	.40	25	
DATE	TIME	SOLIDS, SUM OF CONSTITU- ENTS, DIS- SOLVED (MG/L)	SOLIDS, RESIDUE AT 105 DEG. C, SUS- PENDED (MG/L)	SOLIDS, VOLA- TILE, SUS- PENDED (MG/L)	NITRO- GEN, NITRATE TOTAL (MG/L AS N)	NITRO- GEN, NITRITE TOTAL (MG/L AS N)	NITRO- GEN, NO2+NO3 TOTAL (MG/L AS N)	NITRO- GEN, AMMONIA TOTAL (MG/L AS N)	NITRO- GEN, ORGANIC TOTAL (MG/L AS N)	NITRO- GEN,AM- MONIA + ORGANIC TOTAL (MG/L AS N)	PHOS- PHORUS, TOTAL (MG/L AS P)	CARBON, ORGANIC TOTAL (MG/L AS C)	
JUN 10...		460	10	4	2.6	.410	3.0	4.10	1.5	5.6	<.010	7.4	
DATE	TIME	ARSENIC DIS- SOLVED (UG/L AS AS)	BARIUM, DIS- SOLVED (UG/L AS BA)	CADMIUM DIS- SOLVED (UG/L AS CD)	CHRO- MIUM, DIS- SOLVED (UG/L AS CR)	COPPER, DIS- SOLVED (UG/L AS CU)	IRON, DIS- SOLVED (UG/L AS FE)						
JUN 10...	1300	4	140	1	<10	4	7						
DATE	TIME	LEAD, DIS- SOLVED (UG/L AS PB)	MANGA- NESE, DIS- SOLVED (UG/L AS MN)	MERCURY DIS- SOLVED (UG/L AS HG)	SELE- NIUM, DIS- SOLVED (UG/L AS SE)	SILVER, DIS- SOLVED (UG/L AS AG)	ZINC, DIS- SOLVED (UG/L AS ZN)						
JUN 10...		3	5	<.1	<1	<1	12						
DATE	TIME	AME- TRYNE TOTAL (UG/L)	ATRA- ZINE, TOTAL (UG/L)	CYAN- AZINE TOTAL (UG/L)	METHO- MYL TOTAL (UG/L)	PROME- TONE TOTAL (UG/L)	PROME- TRYNE TOTAL (UG/L)	PRO- PAZINE TOTAL (UG/L)	PROPHAM TOTAL (UG/L)	SEVIN, TOTAL (UG/L)	SIMA- ZINE TOTAL (UG/L)	SIME- TRYNE TOTAL (UG/L)	
JUN 10...	1300	<.10	.10	<.10	<2.0	.1	<.1	<.10	<2.0	<2.0	.20	<.1	

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AVERAGE DISCHARGE-- 50 years, 131 QW (94310 est-14yr).

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
PAY	DEC	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	
1	212	100	135	115	120	130	120	1100	105	104	103	100	
2	140	575	120	115	120	120	115	600	103	104	103	155	
3	137	244	119	115	590	300	115	300	104	110	171	117	
4	129	144	115	115	1920	790	115	200	493	161	279	109	
5	127	124	119	115	250	180	120	150	277	101	204	109	
6	129	120	117	115	255	145	120	130	320	100	748	2350	
7	132	120	117	115	150	130	120	120	151	108	107	747	
8	131	112	113	190	135	120	115	115	1750	101	128	250	
9	129	110	122	250	250	125	250	115	617	120	141	130	
10	129	116	119	300	155	125	500	300	370	112	256	259	
11	127	4200	3260	130	140	130	320	210	1010	108	306	162	
12	131	2070	1120	120	125	500	150	150	251	107	176	124	
13	509	309	390	120	115	130	125	120	139	106	115	160	
14	401	257	191	120	200	140	115	120	137	105	116	132	
15	1450	310	156	120	250	125	110	150	127	170	102	122	
16	255	210	141	120	155	125	110	140	540	124	114	159	
17	316	145	131	130	130	130	110	240	915	97	105	172	
18	502	125	126	125	150	150	115	270	200	101	110	130	
19	315	121	122	120	140	125	115	105	137	99	108	143	
20	250	117	120	120	130	130	477	104	139	101	102	172	
21	463	117	115	120	125	120	261	101	360	101	107	174	
22	805	112	115	120	120	120	172	103	217	90	100	209	
23	820	115	115	115	120	125	129	103	156	90	789	246	
24	401	1130	115	110	115	125	124	100	115	100	391	169	
25	359	765	115	115	120	125	116	492	109	100	130	117	
26	210	190	115	115	125	130	112	198	110	101	111	264	
27	134	575	115	120	125	125	109	423	110	102	120	127	
28	1140	251	115	120	125	120	100	190	107	106	123	173	
29	446	140	125	130	---	120	100	111	102	105	107	159	
30	300	130	120	130	---	125	100	104	104	107	102	120	
31	323	---	115	120	---	130	---	111	---	103	165	---	
TOTAL	10070	14072	8241	4105	6455	5015	4694	5795	9501	3300	5965	7666	
MEAN	322	454	266	132	208	162	156	219	317	109	192	256	
MAX	1450	4200	3260	300	1920	790	500	1100	1750	181	769	2350	
MIN	127	112	113	110	115	120	100	100	102	97	102	109	
AC-FT	21620	20540	16350	8140	12000	7750	9310	13400	18050	6720	11030	15210	

CAL YR 1985	TOTAL	94530	MEAN	299	MAX	4200	MIN	96	AC-FT	107500
WTR YR 1986	TOTAL	87112	MEAN	299	MAX	4200	MIN	97	AC-FT	172000

Risk discharges greater than base discharge of 6000 AQ and maximum (M):

Date	Time	Discharge (AQ)	Grp. height (ft)
Nov 11	2045	*17,300	*35.26
Dec 11	1245	7950	37.64
Feb 3	2315	6350	36.52
Apr 6	1615	6410	38.05

Minimum daily, 97 AQ July 16.

Estimated daily discharges: Dec. 20 to May 19.

\* There was no QW for 1986 wy.

001082

Appendix C-1

Technical Information Concerning the HNu  
(Photo-Ionization Analyzer)

Brand Name: HNu

Instrument Name: Photo-Ionization Analyzer

Manufacturer: HNu Systems, Inc.  
160 Charlemont St.  
Newton Highlands, Ma 02161  
(617) 964-6690

Model: PI- 101

Lamp: 10.2 electron volt

Energy Source: 12 volt, gell cell battery with rechargeable battery: can be  
run on AC by using the recharger.

Calibration Standard: Benzene

Meter Readout: 3 scales are provided for read-out purposes: 0-20, 0-200, and  
0-2000 ppm.

001083

APPENDIX C-2  
 PHOTO-IONIZER (HNU) AND TRICHLOROETHENE (TCE) READINGS  
 FOR SURFACE AND SUBSURFACE SOIL SAMPLES

Shallow Boreholes

Sample Identification	Depth (feet)	HNU Reading (ppm)		TCE Values(ppm)
		In Hole	Samples	
B-1 ST1	0-2'		0	N.A.
B-1 ST2	2-4'		0	N.A.
B-2 ST1	0-2'		0	N.A.
B-2 ST2	2-4'		0	N.A.
B-3 ST1	0-2'		0	0.005
B-3 ST2	2-4'	2.3-4	0.5	0.006
B-4 ST1	0-2'		0	0.008
B-4 ST2	2-4'	1.5	0.7	0.032
B-5 ST1	0-2'	130	130	41
B-5 ST2	2-4'	440	460	87
B-6 ST1	0-2'	0	0	N.A.
B-6 ST2	2-4'	0	0	N.A.
B-7 ST1	0-2'	320	420	150
B-7 ST2	2-4'	220	370	10
B-8 ST1	0-2'	42	10	0.270
B-8 ST2	2-4'	180	250	0.074
B-9 ST1	0-2'	Trace	0	0.700
B-9 ST2	2-4'	0	0	0.085
B-10 ST1	0-2'	3.5	0	N.A.
B-10 ST2	2-4'	0	0	N.A.
B-11 ST1/S1	0-2'	85	67/23	2
B-11 ST2	2-4'	20	70	1
B-12 ST1/S1	0-2'	0	0	3
B-12 ST2	2-4'	0	0	0.088
B-13 ST1	0-2'	0	0	N.A.
B-13 ST2	2-4'	0	0	N.A.
B-14 ST1	0-2'	0	0	0.022
B-14 ST2	2-4'	0	0	0.025
B-15 ST1	0-2'	0	0	N.A.
B-15 ST2	2-4'	0	0	N.A.
B-16 ST1	0-2'	0	0	N.A.
B-16 ST2	2-4'	0	0	N.A.
B-17 ST1	0-2'	0	0	N.A.
B-17 ST2	2-4'	0	0	N.A.
B-18 ST1	0-2'	0	0	N.A.
B-18 ST2	2-4'	0	0	N.A.

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APPENDIX C-2  
 PHOTO-IONIZER (HNU) AND TRICHLOROETHENE (TCE) READINGS  
 FOR SURFACE AND SUBSURFACE SOIL SAMPLES  
 (Cont'd)

Monitor Wells and Deep Boreholes

<u>Sample Identification</u>	<u>Depth (feet)</u>	<u>HNU Reading (ppm)</u>		<u>TCE Values(ppm)</u>
		<u>In Hole</u>	<u>Samples</u>	
MW1 ST1	0-1'		0	N.A.
MW1 ST2	2.5-4'		0	N.A.
MW1 ST3	4-6'		40	N.A.
MW1 ST4	6-8'		1	N.A.
MW1 ST5	8-10'		0	N.A.
MW1 ST6	10-12'		0	N.A.
MW1 ST7	12-14'		0	N.A.
MW1 ST8	14-16'		0-Trace	N.A.
MW1 ST9	16-18'		Trace - .1	N.A.
MW1 ST10	18-20'		0	N.A.
MW1 ST11	20-22'		0	N.A.
MW1 ST12	22-22.75'		0	N.A.
MW1 ST13	22.75-27.75'		0	N.A.
MW1 ST14			0	N.A.
MW1 ST15	27.75-33.5'		0	N.A.
MW1 ST16			0	N.A.
DB1 ST1	0-1'		0	N.A.
DB1 ST2	2.5-4'		200	N.A.
DB1 ST3	5-6.7'		30	N.A.
DB1 ST4	7.5-9'		400	N.A.
DB1 CM1A	9-13'		80	N.A.
DB1 CM1B				
DB1 CM2A	13-18'		11.5	N.A.
DB1 CM2B				
DB1 CM3A	18-23'		0	N.A.
DB1 CM3B				
DB1 CM4A/4B	23-28'		56	N.A.
DB1 CM5A/5B	28-33'		220	N.A.
DB1 CM6A	33-38'		220	N.A.
DB1 CM6B				

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APPENDIX C-2  
 PHOTO-IONIZER (HNU) AND TRICHLOROETHENE (TCE) READINGS  
 FOR SURFACE AND SUBSURFACE SOIL SAMPLES  
 (Cont'd)

Monitor Wells and Deep Boreholes (Cont'd)

<u>Sample Identification</u>	<u>Depth (feet)</u>	<u>HNU Reading (ppm)</u>		<u>TCE Values(ppm)</u>
		<u>In Hole</u>	<u>Samples</u>	
DB2 ST1	0-1'		44	N.A.
DB2 ST2	2.5-4'		440	N.A.
DB2 ST3	5-6.5'		460	N.A.
DB2 ST4	7.5-9'		460	N.A.
DB2 CM1A	9-13'		220	N.A.
DB2 CM1B				
DB2 CM2A	13-18'		17	N.A.
DB2 CM2B				
DB2 CM3A	18-23'		340	N.A.
DB2 CM3B				
DB2 CM4A	23-28'		360	N.A.
DB2 CM4B				
DB2 CM5A	28-33'		240	N.A.
DB2 CM5B				
DB2 CM6A	33-38'		118	N.A.
DB2 CM6B				
DB2 CM7A	38-43'		220	N.A.
DB2 CM7B				
DB3 ST1	0-1'		0	N.A.
DB3 ST2	2.5-4'		0	N.A.
DB3 ST3	5-6.5'		0	N.A.
DB3 ST4	7.5-9'		0	N.A.
DB3 CM1A	9-14'		0	N.A.
DB3 CM2A	14-19'		0	N.A.
DB3 CM2B				
DB3 CM3A	19-24'		0	N.A.
DB3 CM3B				
DB3 CM4A	24-29'		50	18
DB3 CM4B				
DB3 CM5A	29-34'		11.8	N.A.
DB3 CM5B				
DB3 CM6A	34-39'		9.8	40

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APPENDIX C-2  
 PHOTO-IONIZER (HNU) AND TRICHLOROETHENE (TCE) READINGS  
 FOR SURFACE AND SUBSURFACE SOIL SAMPLES  
 (Cont'd)

Monitor Wells and Deep Boreholes (Cont'd)

<u>Sample Identification</u>	<u>Depth (feet)</u>	<u>HNU Reading (ppm)</u>		<u>TCE Values(ppr</u>
		<u>In Hole</u>	<u>Samples</u>	
DB4 ST1	0-1'		0	N.A.
DB4 ST2	2.5-4'		0	N.A.
DB4 ST3	5-6.5'		0	N.A.
DB4 ST4	7.5-9'		0	N.A.
DB4 CM1A	9-13.5'		0.6	N.A.
DB4 CM1B				
DB4 CM2A	13.5-18.5'		0.6	N.A.
DB4 CM2B				
DB4 CM3A	18.5-23.5'		5.2	N.A.
DB4 CM3B				
DB4 CM4A	23.5-28.5'		7.8	5.7
DB4 CM4B				
DB4 CM5A	28.5-33.5'		0.4	N.A.
DB4 CM5B				
DB4 CM6A	33.5-38.5'		170	43.0
DB4 CM6B				
DB4 CM7A	38.5-43.5'		1.6	N.A.
DB4 CM7B				
DB5 ST1	0-1'		0	N.A.
DB5 ST2	2.5-4'		0	N.A.
DB5 ST3	5-6.5'		0	N.A.
DB5 ST4	7.5-9'		0	N.A.
DB5 CM1A	9-13'		0	N.A.
DB5 CM1B				
DB5 CM2A	13-18'		0	N.A.
DB5 CM2B				
DB5 CM3A	19-23'		0	N.A.
DB5 CM3B				
DB5 CM4A	23-28'		80	5
DB5 CM4B				
DB5 CM5A	28-33'		5.4	N.A.
DB5 CM5B				
DB5 CM6A	33-38'			
DB5 CM6B			1.2/11	0.008
DB5 CM7A	38-43'		0	N.A.
DB5 CM7B				
DB5 SB1	43-44		15.3	N.A.

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APPENDIX C-2  
 PHOTO-IONIZER (HNU) AND TRICHLOROETHENE (TCE) READINGS  
 FOR SURFACE AND SUBSURFACE SOIL SAMPLES  
 (Cont'd)

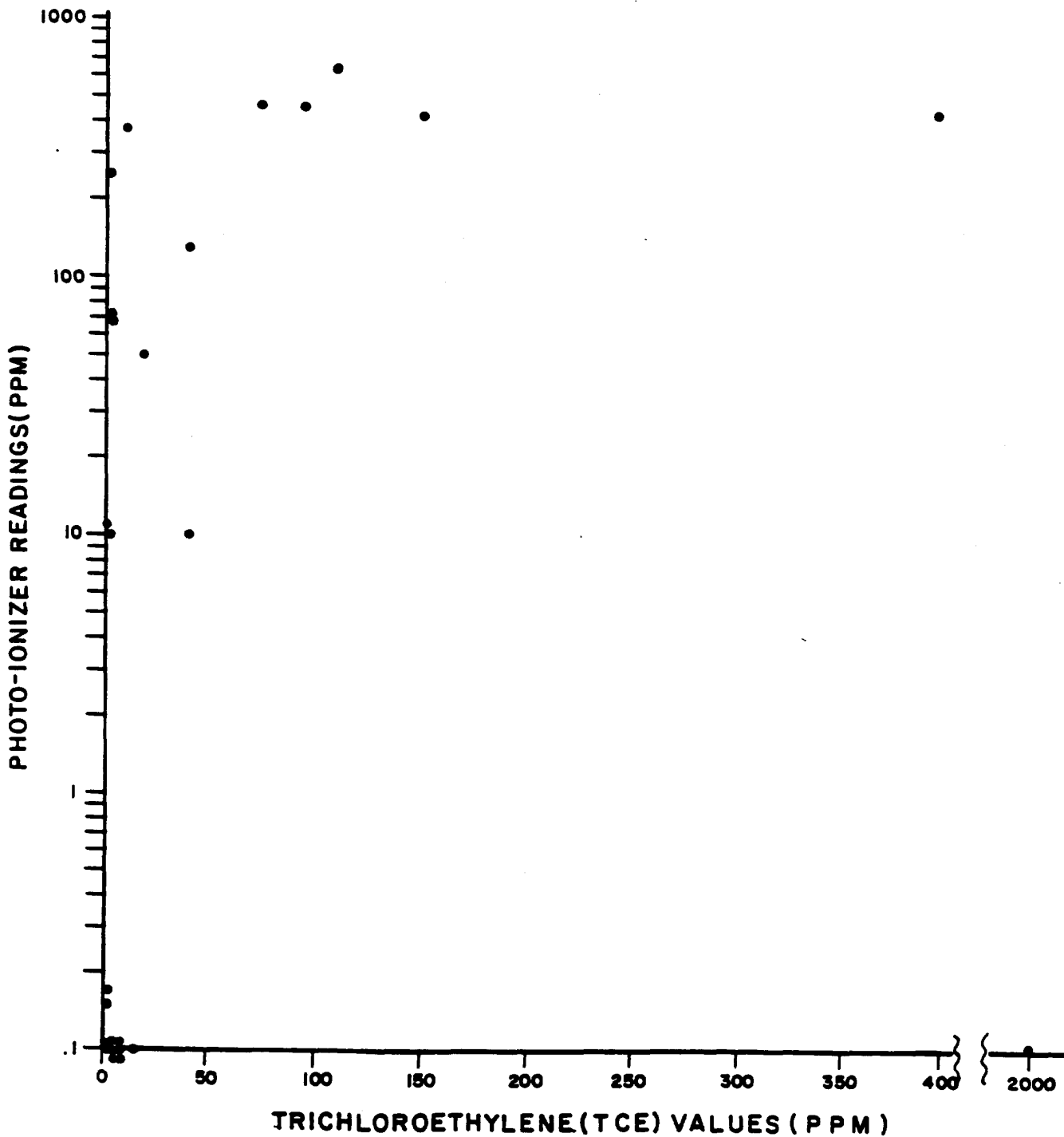
Monitor Wells and Deep Boreholes (Cont'd)

<u>Sample Identification</u>	<u>Depth (feet)</u>	<u>HNU Reading (ppm)</u>		<u>TCE Values(ppm)</u>
		<u>In Hole</u>	<u>Samples</u>	
MW4 S1	0-5'		20	N.A.
MW4 S2	5-9'		20	N.A.
MW6 S1	0-5'		0	N.A.
MW6 S2	5-9'		0	N.A.
MW6 S3	25-30'		0	N.A.
MW3 S1	0-5'		100	N.A.
MW3 S2	5-9'		47	N.A.
MW3 S3	9-10'		400	390
	10-15'	cuttings	100	N.A.
	15-20'	cuttings	20-300	N.A.
	20'	cuttings	25	N.A.
MW3	20-25'	cuttings	300-400	N.A.
		auger	50-60	N.A.
MW3 S4	25-26'		460	75
	30-35'			N.A.
	40-45'	cuttings	400	N.A.
		cuttings	0-180'	N.A.
		cuttings	30-40'	N.A.
MW3 SB1	54-55.5		640	110
MW3 SB2	65-66.5		300	N.A.
MW3 SB3	89-90.5		0	15
MW3 SB4	94-95.5		0-.4	2000

**Key to Abbreviations:**

ST - Shelby tube  
 SM - Core barrel material  
 SB - Split barrel  
 S - Auger cuttings  
 NA - Not analyzed

001088



APPENDIX C-3  
CORRELATION BETWEEN PHOTO-IONIZER READINGS  
AND TRICHLOROETHYLENE VALUES

**RADIAN**  
CORPORATION

APPENDIX C-4  
SAMPLE METHODS AND PRESERVATION REQUIREMENTS

Sample	Sample Type	No.	Container	Size	Analytical Parameter	Procedures	Preservation	Maximum Holding Time
Water Well	Water	1	Glass, Teflon-lined septum	40 ml	TCE	8010	Cool, 4°C	14 days
Soil & Sediment	Soil	51	Glass, Teflon-lined cap	100 grams	TCE	8080	Cool, 4°C	14 days
		4		40 grams	PCB	8010		7 days before and
		1		100 grams	POP	8270, 8240	Cool, 4°C	40 days after
		3		100 grams	Dioxin	8280		extraction
Shallow Soil Boring	Soil	37	Glass, Teflon-lined cap	100 grams	TCE	8080	Cool, 4°C	14 days
		18		40 grams	PCB	8010		7 days before and
		4		100 grams	POP	8270, 8240	Cool, 4°C	40 days after
		1		100 grams	Dioxin	8280		extraction
Deep Soil Boring	Soil	50	Glass, Teflon-lined cap	100 grams	TCE	8080	Cool, 4°C	14 days
		4		40 grams	PCB	8010		7 days before and
		1		100 grams	POP	8270, 8240	Cool, 4°C	40 days after extraction
Monitor Well	Soil	16	Glass, Teflon-lined cap	100 grams	TCE	8080	Cool, 4°C	14 days
		4		40 grams	PCB	8010		7 days before and
		1		100 grams	POP	8270	Cool, 4°C	40 days after extraction
Groundwater	Water	15	Glass, Teflon-lined cap	40 ml	TCE	8010	Cool, 4°C	14 days
		4		40 ml	VPOP	CL624	Cool, 4°C	14 days
Storm Water	Water	7	Glass, Teflon-lined cap	1 liter	PCB	8080	Cool, 4°C	7 days before and
		2		40 ml	POP	CL624, CL625	Cool, 4°C	40 days after extraction
Ambient Air	Air	4	Filter in Plastic Bag		Particles PCB	Gravimetric 8080	Cool, 4°C	7 days before and 40 days after extraction

001090

**APPENDIX D - 1**  
**MONITOR WELL CONSTRUCTION DETAILS**

001091

**APPENDIX D-1**  
**MONITOR WELL CONSTRUCTION DETAILS\***

	<u>MW-1</u>	<u>MW-2</u>	<u>MW-3</u>	<u>MW-4</u>	<u>MW-5</u>	<u>MW-6</u>	<u>MW-7</u>
PVC Surface Casing	0-10'	0-10'	0-10'	0-10'	0-10'	0-10'	0-10'
Cement-bentonite grout	0-26'	0-25'	0-44'	0-25'	0-27'	0-22'6"	0-25.5'
Bentonite seal	26-27.5'	25-26'	71-76'	25-27'	25-27'	22'6"-26'8"	25.5'-27'
Sand pack	27.5'-46'	26-43'	76-99'	27-43'	27-43.5'	26'8"-44'	27-44'
Screen	30-40'	28-38'	84-94'	28-38'	28.5'-38.5'	29-39'	29-39'
Sediment trap	40-45'	38-43'	94-99'	38-43'	38.5'-43.5'	39-44'	3'
Bentonite Seal	45-48.5'		94-99'				
Total Depth	48.5'	43'	99'	43'	43.5'	44'	44'

\* All depths recorded in feet.

001092

**APPENDIX D - 2**  
**WELL COMPLETION LOGS**

001093

RADIAN  
CORPORATION

WELL COMPLETION LOG: SHEET 1/2

Boring or Well No. Monitor Well 1 Project Industrial Transformer  
Location Houston, Texas Log Recorded by Mark A. Brotherton

Construction started January 19, 1987 completed January 20, 1987  
Development started February 5, 1987 completed February 5, 1987

Total depth drilled (ft) 48.5' Hole diameter 6"  
Drilling method Hollow stem auger  
Problems encountered during drilling None

Water source for drilling and completion procedures City water

Number and type of samples collected 11 Shelby tube sampler

Sample interval (ft-ft) Every 2' to 22' depth then approximately every 5' to T.D.  
Storage method(s) Plastic ziplock bags + drummed

Casing type PVC Diameter 8" Depth of casing (ft) 10'  
Casing type SCH 40' SS Diameter 2" Depth of casing (ft) 48.5'  
Screen type Stainless steel, wire wrapped Diameter 2"  
Slot size .010" Screen interval (ft-ft) 40-30'  
Type(s) of glue used to join casing All joints are flush joint threaded; no glue used

Type of gravel pack used #375 Type 1 Amount of gravel pack used 3.25 cu.ft.  
Grain size distribution of gravel pack All retained on #10 sieve  
Lithology of gravel pack Quartz & Chert  
Source (company and quarry/pit) Tex Blast

Interval of gravel pack (ft-ft) 46-27.5'  
Interval of bentonite seal (ft-ft) 27.5-26'  
Interval of grouting (ft-ft) 26'- surface

Description of security measures Protective casing and padlock

Padlock ID No. Masterlock 2404 Location of key(s) Radian-Houston

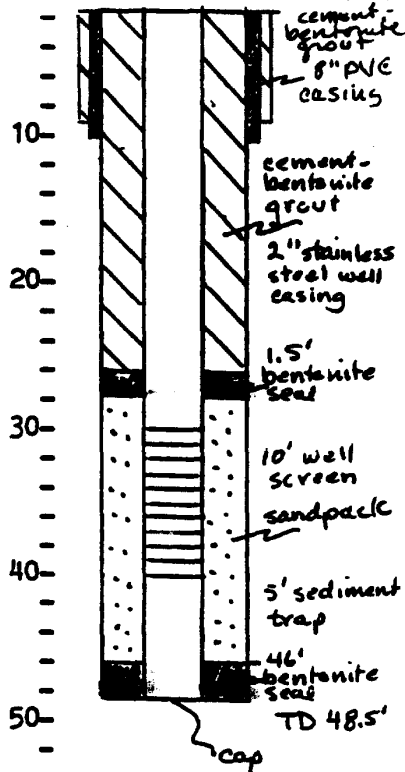
001094

**RADIAN  
CORPORATION**

**WELL COMPLETION LOG: SHEET 2/2**

Boring or Well No. Monitor Well 1 Project Industrial Transformer  
Location Houston, Texas Log Recorded by Mark A. Brotherton

**CONSTRUCTION SCHEMATIC (ft)**



Static level of water before 5.25' (ft) and after            (ft) development           

Development started 2-5-87 and ended 2-5-87

Water Quantity discharged during development 39 gal.

Type, size/capacity of pump or bailer used for development Air compressor

Depth of open hole inside well 48.5'

Before development (ft) NA After development (ft) NA

**Development Record of Discharge and Sediment**

Time	Clar/Clr. Discharge	Odor of Discharge	Lithology/ Grain Size	Temp. FO	Conduc- tivity	Salinity
-	Tannish/ yellow/red dirty	"Sweet" and somewhat strong		21.5	4760	3 ppt
12:25pm	"	"		21.5	5200	3.5
1400	"	"		22.5	5300	3.3
-	"	"		22.0	5000	3.2



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WELL COMPLETION LOG: SHEET 1/2

Boring or Well No. Deep Bore 2/Mon. Well 2 Project Industrial Transformer  
Location Houston Texas Log Recorded by Mark A. Brotherton

Construction started January 23, 1987 completed January 23, 1987  
Development started February 9, 1987 completed February 9, 1987

Total depth drilled (ft) 43.0' Hole diameter 6"  
Drilling method Hollow Stem Auger  
Problems encountered during drilling None  
Water source for drilling and completion procedures City Water

Number and type of samples collected 4 Shelby Tube: 7 Core Barrel  
Sample interval (ft-ft) Shelby Tube 1st ft., then 3 intervals of 1.5' to 9' depth  
5' intervals of core barrel sample to 43.0'  
Storage method(s) Plastic ziplock bags and drummed

Casing type PVC 10' length Diameter 8" Depth of casing (ft) 10'  
Casing type SCH 40' 22 Diameter 2" Depth of casing (ft) 43.0'  
Screen type Stainless Steel, wire wrapped Diameter 2"  
Slot size .010" Screen interval (ft-ft) 38'-28'  
Type(s) of glue used to join casing All joints are flush joint threaded: no glue used

Type of gravel pack used #375 Type 1 Amount of gravel pack used 2.25 cu.ft.  
Grain size distribution of gravel pack All retained on #10 sieve  
Lithology of gravel pack Quartz and chert  
Source (company and quarry/pit) Tex Blast

Interval of gravel pack (ft-ft) 43'-26'  
Interval of bentonite seal (ft-ft) 26'-25'  
Interval of grouting (ft-ft) 25'- surface

Description of security measures Protective casing and padlock

Padlock ID No. Masterlock #2211 Location of key(s) Radian - Houston

001096

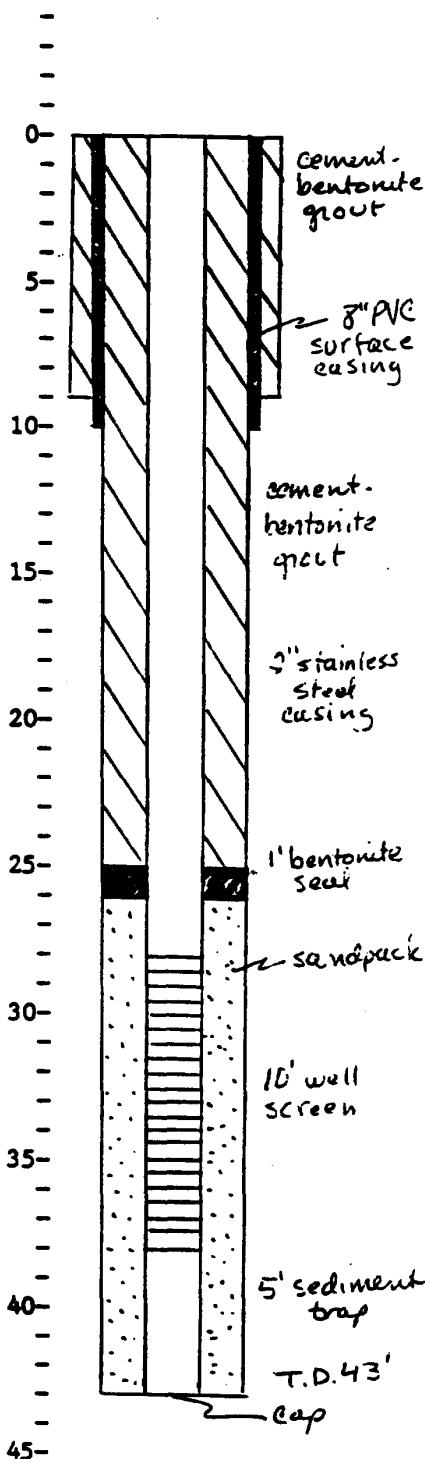
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WELL COMPLETION LOG: SHEET 2/2

Boring or Well No. Monitor Well #2  
Location Houston, Texas

Project Industrial Transformer  
Log Recorded by Mark A. Brotherton

CONSTRUCTION SCHEMATIC (ft)



Static level of water before 4.7' (ft) and after  
NA (ft) development  
Development started 2-9-87 and ended 2-9-87  
Water Quantity discharged during development 37.25 gal.  
Type, size/capacity of pump or bailer used for development  
Air Compressor

Depth of open hole inside well 43.0'  
Before development (ft) NA After development (ft) IA

Development Record of Discharge and Sediment

Time	Clar/Clr. Discharge	Odor of Discharge	Lithology/ Grain Size	Conduc- tivity	Salinity
2-9-87					
14:45	Yellowish/ tan	"sweet" and strong	silt	24°	1330 .75 ppt
15:15	"	"	"	24.5°	3520 2.0 ppt
15:45	"	"	"	23.0°	3625 2.0 ppt
16:30	"	"	"	22.5°	3690 2.2 ppt

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WELL COMPLETION LOG: SHEET 1/2

Boring or Well No. Monitor Well 3 Project Industrial Transformer  
Location Houston, Texas Log Recorded by Mark A. Brotherton

Construction started January 28, 1987 completed February 4, 1987  
Development started February 9, 1987 completed February 9, 1987

Total depth drilled (ft) 99' Hole diameter 6"  
Drilling method Hollow stem auger  
Problems encountered during drilling None

Water source for drilling and completion procedures City water

Number and type of samples collected 4 auger cuttings, 4 split barrel

Sample interval (ft-ft) S1@ 0-5'; S2@ 5-9'; S3@ 9-10'; S4@ 25-26'; SB1@ 54.4-56';  
SB2@ 65-66.5'; SB-3@ 89-90'; SB4@ 94-95.5';  
Storage method(s) Plastic ziplock bags + drummed

Casing type PVC Diameter 12" 8" Depth of casing (ft) 10', 44'  
Casing type SCH 40 SS Diameter 2" Depth of casing (ft) 99'  
Screen type Wire wrapped stainless steel Diameter 2"  
Slot size .010" Screen interval (ft-ft) 94-84'  
Type(s) of glue used to join casing All joints are flush threaded; no glues were used

Type of gravel pack used #375 Type 1 Amount of gravel pack used 3.15 cu.ft.  
Grain size distribution of gravel pack All retained on #10 sieve  
Lithology of gravel pack Quartz & chert  
Source (company and quarry/pit) Tex Blast

Interval of gravel pack (ft-ft) 99-76'  
Interval of bentonite seal (ft-ft) 10 gallons of mud, approximately 5', 76-71'  
Interval of grouting (ft-ft) 71' surface

Description of security measures Protective casing and padlock

Padlock ID No. Masterlock 2846 Location of key(s) Radian-Houston

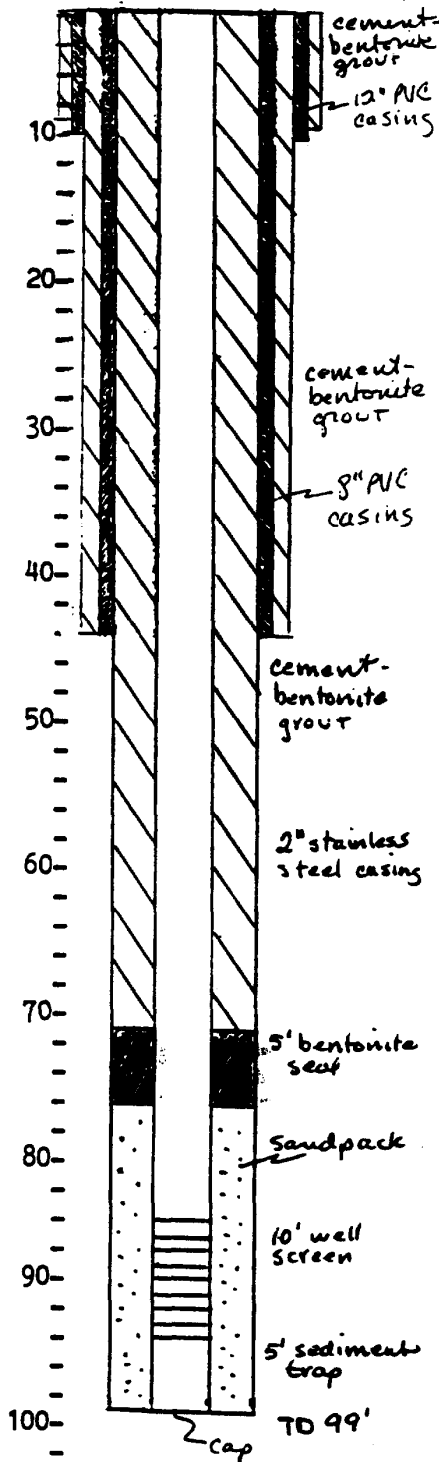
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WELL COMPLETION LOG: SHEET 2/2

Boring or Well No. Monitor Well 3 Project Industrial Transformer  
Location Houston, Texas Log Recorded by Mark A. Brotherton

CONSTRUCTION SCHEMATIC (ft)



Static level of water before 26.90' (ft) and after  
NA (ft) development  
Development started 2-9-87 and ended 2-9-87  
Water Quantity discharged during development 63.3 gal.  
Type, size/capacity of pump or bailer used for development  
Air compressor

Depth of open hole inside well 99'  
Before development (ft) NA After development (ft) NA

Development Record of Discharge and Sediment

Time	Clar/Clr. Discharge	Odor of Discharge	Lithology/ Grain Size	Temp F°	Conduc- tivity	Salinity
1110	Reddish dirty	Very slight "sweet smell"		21.0	1090	0.5 ppt
1300	"	"		26.0	1960	1.0
1345	"	"		23.5	1320	1.0
1355	"	"		22.0	1480	1.0
1415	"	"		23.5	1710	1.0

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WELL COMPLETION LOG: SHEET 1/2

Boring or Well No. Monitor Well 4 Project Industrial Transformer  
Location Houston, Texas Log Recorded by Mark A. Brotherton

Construction started February 4, 1987 completed February 4, 1987  
Development started February 6, 1987 completed February 9, 1987

Total depth drilled (ft) 43' Hole diameter 6"  
Drilling method Hollow stem auger  
Problems encountered during drilling None  
Water source for drilling and completion procedures City water

Number and type of samples collected 4 Shelby tube; 7 core barrel

Sample interval (ft-ft) Shelby tube 1st ft. then 3 intervals of 1.5' to 9' depth;  
5' intervals of core barrel sample to 43' depth  
Storage method(s) Plastic ziplock bags + drummed

Casing type PVC Diameter 8' Depth of casing (ft) 10'  
Casing type SCH 40 SS Diameter 2" Depth of casing (ft) 43'  
Screen type Wire wrapped stainless steel Diameter 2"  
Slot size .010" Screen interval (ft-ft) 38-28'  
Type(s) of glue used to join casing All joints are flush joint threaded; no glue used

Type of gravel pack used #375 Type 1 Amount of gravel pack used 2 cu.ft.  
Grain size distribution of gravel pack All retained on #10 sieve  
Lithology of gravel pack Quartz & chert  
Source (company and quarry/pit) Tex Blast

Interval of gravel pack (ft-ft) 43-27'  
Interval of bentonite seal (ft-ft) 27-25'  
Interval of grouting (ft-ft) 25' - surface

Description of security measures Protective casing and padlock

Padlock ID No. Masterlock 2389 Location of key(s) Radian-Houston

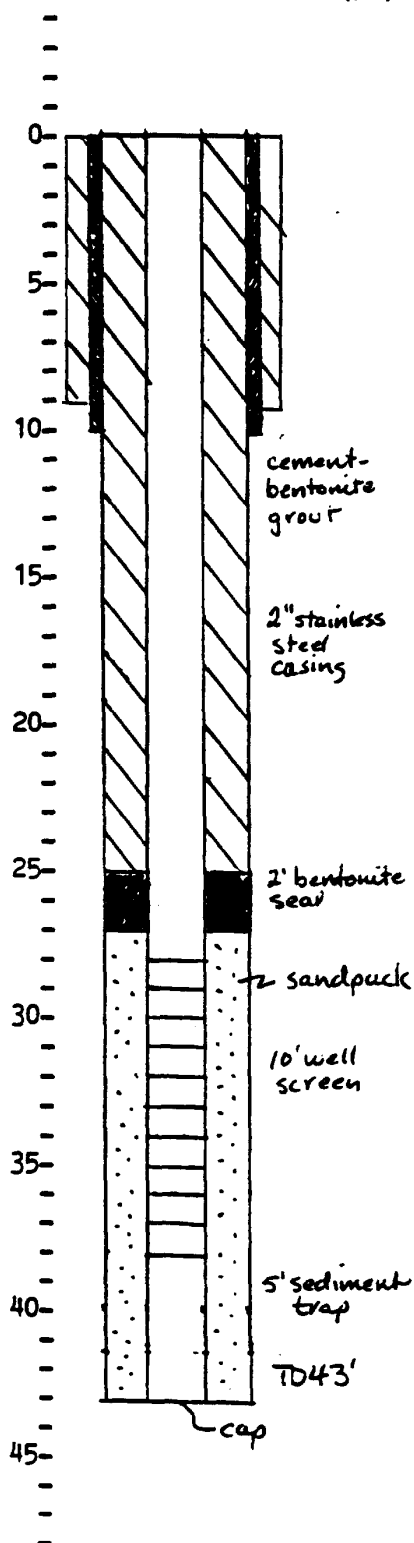
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WELL COMPLETION LOG: SHEET 2/2

Boring or Well No. Monitor Well 4 Project Industrial Transformer  
Location Houston, Texas Log Recorded by Mark A. Brotherton

CONSTRUCTION SCHEMATIC (ft)



Static level of water before 4.2' (ft) and after NA (ft) development  
Development started 2-6-87 and ended 2-6-87  
Water Quantity discharged during development 36.09 gal.  
Type, size/capacity of pump or bailer used for development Air compressor

Depth of open hole inside well 43'  
Before development (ft) NA After development (ft) NA

Development Record of Discharge and Sediment

Time	Clar/Clr. Discharge	Odor of Discharge	Lithology/ Grain Size	Temp FO	Conduc- tivity	Salinity
2-6-87						
1445	Yellowish/ tan/red	"Sweet" and strong		19.5	1105	0.75 ppt
1630	"	"		18.0	3015	2.0
2-9-87						
0925	"	"		17.0	3080	2.0
1000	"	"		16.5	3105	2.0
1015	"	"		17.5	3210	2.0

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WELL COMPLETION LOG: SHEET 1/2

Deep Bore 4  
Boring or Well No. Monitor Well 5 Project Industrial Transformer  
Location Houston, Texas Log Recorded by Mark A. Brotherton

Construction started January 27, 1987 completed January 27, 1987  
Development started February 6, 1987 completed February 9, 1987

Total depth drilled (ft) 435' Hole diameter 6"  
Drilling method Hollow stem auger  
Problems encountered during drilling None  
Water source for drilling and completion procedures City water

Number and type of samples collected 4 Shelby tubes; 7 core barrel

Sample interval (ft-ft) Shelby tube first 1' then 3 intervals of 1.5 down to 9';  
core barrel about every 5' to total depth 43.5'  
Storage method(s) Plastic ziplock bags and drummed

Casing type PVC Diameter 8" Depth of casing (ft) 10'  
Casing type SCH 40 SS Diameter 2" Depth of casing (ft) 43.5  
Screen type Wire wrapped stainless steel Diameter 2"  
Slot size .010" Screen interval (ft-ft) 38.5-28.5'  
Type(s) of glue used to join casing All joints are flush threaded; no glues used

Type of gravel pack used #375 Type 1 Amount of gravel pack used 2 cu.ft.  
Grain size distribution of gravel pack All retained on #10 sieve  
Lithology of gravel pack Quartz and chert  
Source (company and quarry/pit) Tex Blast

Interval of gravel pack (ft-ft) 43.5'-27'  
Interval of bentonite seal (ft-ft) 27-25'  
Interval of grouting (ft-ft) 25'-surface

Description of security measures Protective casing and padlock

Padlock ID No. 2170 Masterlock Location of key(s) Radian-Houston

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WELL COMPLETION LOG: SHEET 2/2

Deep Bore 4

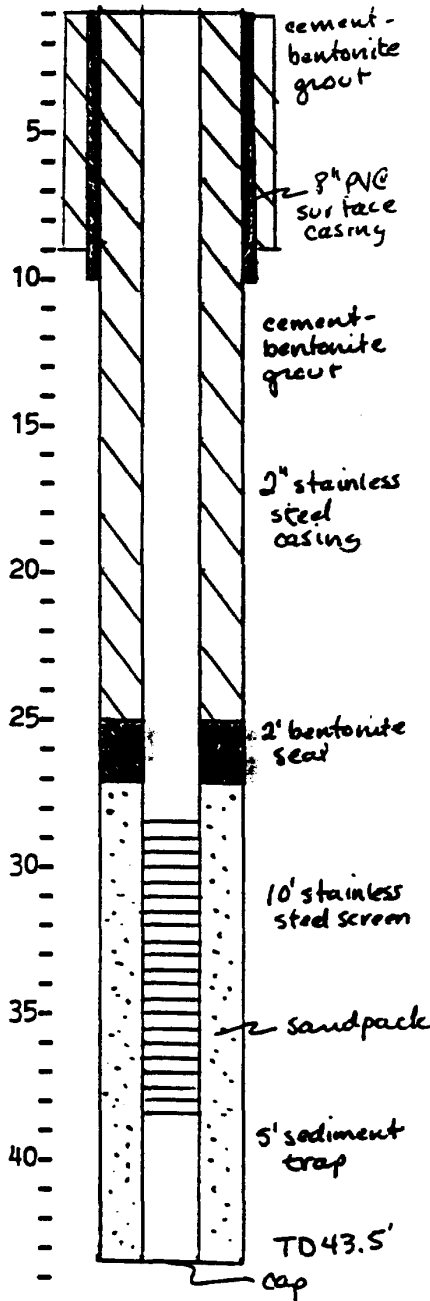
Boring or Well No. Monitor Well 5

Project Industrial Transformer

Location Houston, Texas

Log Recorded by Mark A. Brotherton

CONSTRUCTION SCHEMATIC (ft)



Static level of water before 5.04' (ft) and after NA (ft) development

Development started 2-6-87 and ended 2-9-87

Water Quantity discharged during development 37 gal.

Type, size/capacity of pump or bailer used for development Air compressor

Depth of open hole inside well 43.5'

Before development (ft) NA After development (ft) 1

Development Record of Discharge and Sediment

Time	Clar/Clr. Discharge	Odor of Discharge	Lithology/ Grain Size	Temp FO	Conduc- tivity	Salinity
2-6-87						
1207	Yellowish/ tan/red	"Sweet" and strong		18.5	470	0.1 ppt
1345	"	"		18.0	2750	2.0 ppt
1410	"	"		19.0	2850	2.0
2-9-87						
1710	"	"		18.0	2890	2.0
1720	"	"		18.0	2980	2.0



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WELL COMPLETION LOG: SHEET 1/2

Boring or Well No. Monitor Well 6 Project Industrial Transformer  
Location Houston, Texas Log Recorded by Mark A. Brotherton

Construction started January 28, 1987 completed January 29, 1987  
Development started February 6, 1987 completed February 6, 1987

Total depth drilled (ft) 44' Hole diameter 6"  
Drilling method Hollow stem auger  
Problems encountered during drilling None

Water source for drilling and completion procedures City water

Number and type of samples collected 3 auger cuttings

Sample interval (ft-ft) 0-5', 5-9', and 25-30'  
Storage method(s) Plastic ziplock bags

Casing type PVC Diameter 8" Depth of casing (ft) 10'  
Casing type SCH 40 SS Diameter 2" Depth of casing (ft) 44'  
Screen type Wire wrapped stainless steel Diameter 2"  
Slot size .010" Screen interval (ft-ft) 39-29'  
Type(s) of glue used to join casing All joints are flush joint threaded; no glues used

Type of gravel pack used #375 Type 1 Amount of gravel pack used 2.15 cu.ft.  
Grain size distribution of gravel pack All retained on #10 sieve  
Lithology of gravel pack Quartz and chert  
Source (company and quarry/pit) Tex Blast

Interval of gravel pack (ft-ft) 44-26'8"  
Interval of bentonite seal (ft-ft) 26'8" - 22'6"  
Interval of grouting (ft-ft) 22'6" to surface

Description of security measures Protective casing and padlock

Padlock ID No. Masterlock 2450 Location of key(s) Radian-Houston

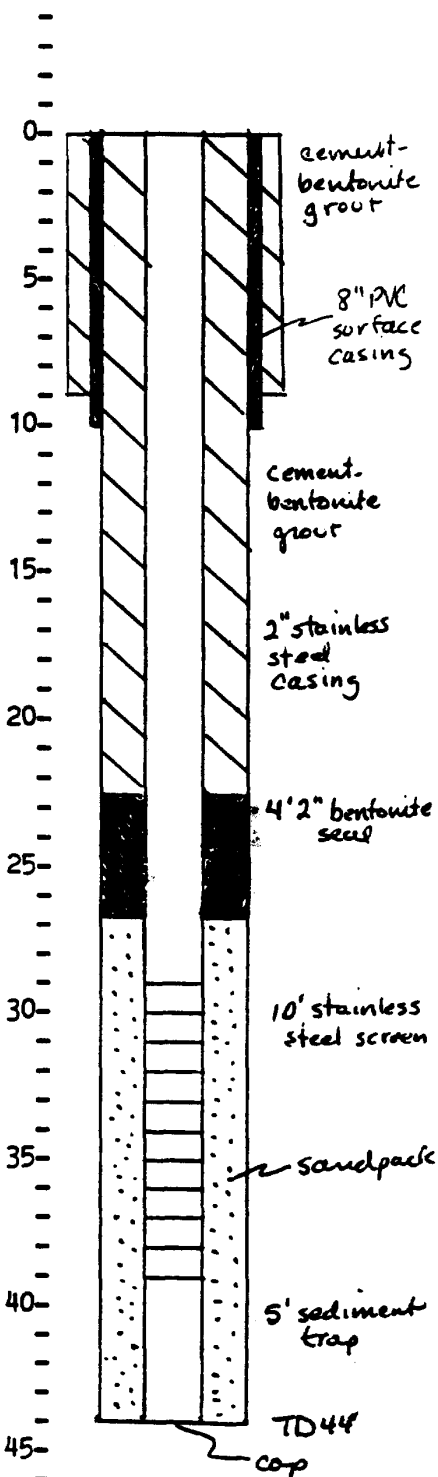
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WELL COMPLETION LOG: SHEET 2/2

Boring or Well No. Monitor Well 6 Project Industrial Transformer  
Location Houston, Texas Log Recorded by Mark A. Brotherton

CONSTRUCTION SCHEMATIC (ft)



Static level of water before 4.82' (ft) and after  
NA (ft) development  
Development started 2-6-87 and ended 2-6-87  
Water Quantity discharged during development 39 gal.  
Type, size/capacity of pump or bailer used for development  
Air compressor

Depth of open hole inside well 44'  
Before development (ft) NA After development (ft) IA

Development Record of Discharge and Sediment

Time	Clar/Clr. Discharge	Odor of Discharge	Lithology/ Grain Size	Temp FO	Conduc- tivity	Salinity
0945	Tannish/ yellow/red	"Sweet" and strong		20.0	540	0.5 ppt
1045	"	"		20.5	2240	1.5 ppt
1120	"	"		22.5	3330	2.0 ppt
1130	"	"		21.0	3220	2.0 ppt
1135	"	"		20.0	3200	2.0 ppt

001105

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CORPORATION

WELL COMPLETION LOG: SHEET 1/2

Deep Bore 5  
Boring or Well No. Monitor Well 7 Project Industrial Transformer  
Location Houston, Texas Log Recorded by Mark A. Brotherton

Construction started January 28, 1987 completed January 28, 1987  
Development started February 5, 1987 completed February 5, 1987

Total depth drilled (ft) 44' Hole diameter 6"  
Drilling method Hollow stem auger  
Problems encountered during drilling None

Water source for drilling and completion procedures City water

Number and type of samples collected 4 Shelby tube, 7 core barrel, 1 split spoon

Sample interval (ft-ft) Shelby tube 1st ft., then 3 intervals of 1.5' to 9' depth;  
core barrel every 5' to 43' depth; 1 split spoon 43'-44' depth  
Storage method(s) Plastic ziplock bags

Casing type PVC Diameter 8" Depth of casing (ft) 10'  
Casing type SCH 20 SS Diameter 2" Depth of casing (ft) 44'  
Screen type Wire wrapped stainless steel Diameter 2"  
Slot size .010 Screen interval (ft-ft) 39-29'  
Type(s) of glue used to join casing All joints are flush threaded; no glue used

Type of gravel pack used #375 Type 1 Amount of gravel pack used 3 cu.ft.  
Grain size distribution of gravel pack All retained on #10 sieve  
Lithology of gravel pack Quartz and chert  
Source (company and quarry/pit) Tex Blast

Interval of gravel pack (ft-ft) 44-27'  
Interval of bentonite seal (ft-ft) 27-25.5'  
Interval of grouting (ft-ft) 25.5' to surface

Description of security measures Protective casing and padlock

Padlock ID No. Masterlock 2164 Location of key(s) Radian-Houston

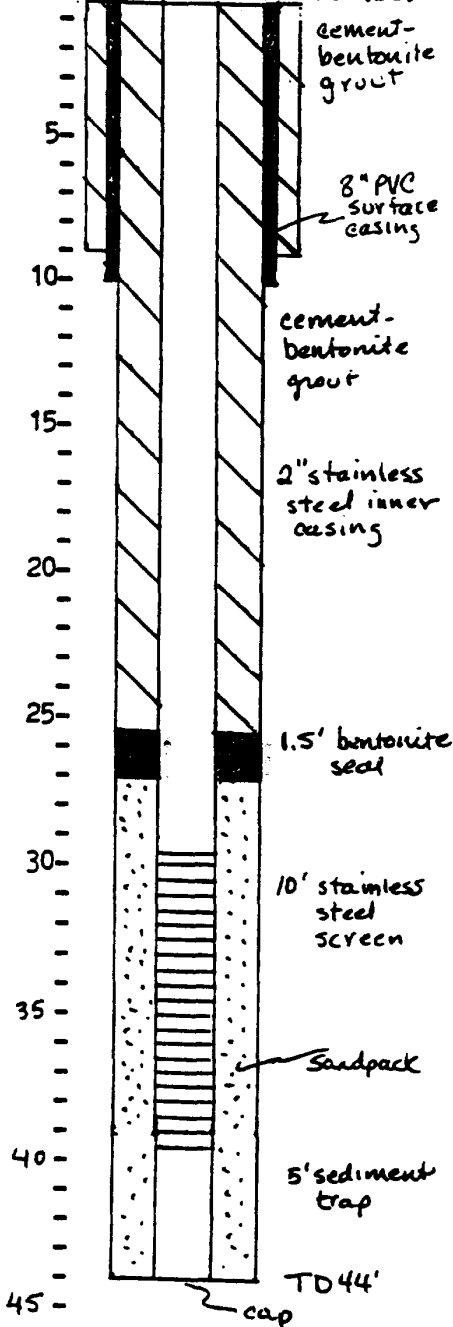
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CORPORATION

WELL COMPLETION LOG: SHEET 2/2

Deep Bore 5  
Boring or Well No. Monitor Well 7 Project Industrial Transformer  
Location Houston, Texas Log Recorded by Mark A. Brotherton

CONSTRUCTION SCHEMATIC (ft)



Static level of water before 3.5' (ft) and after NA (ft) development  
Development started 2-5-87 and ended 2-5-87  
Water Quantity discharged during development 39 gal.  
Type, size/capacity of pump or bailer used for development Air compressor

Depth of open hole inside well 44'  
Before development (ft) NA After development (ft) NA

Development Record of Discharge and Sediment

Time	Clar/Clr. Discharge	Odor of Discharge	Lithology/ Grain Size	Temp FO	Conduc- tivity	Salinity
1550	Tannish/ yellow/red	"Sweet" strong		19.5	1795	1.0 ppt
1610	"	"		20.5	3300	2.0 ppt
1627	"	"		20.0	3520	1.5 ppt
1653	"	"		20.0	3545	2.0 ppt

001107

APPENDIX E-1

001108

Appendix E-1  
Determination of Static Water Levels\*

Date of Measurements: 2-5-87

<u>Well Identification</u>	<u>Top of Casing Elevation Above M.S.L.</u>	<u>Distance to Water Level</u>	<u>Elevation of Groundwater Above M.S.L.</u>
MW1	50.02	not measured	-
MW2	49.70	7.16	42.54
MW3**	51.43	29.90	21.53
MW4	48.70	6.20	42.50
MW5	49.49	6.54	42.95
MW6	51.29	8.32	42.97
MW7	50.33	7.16	43.17

Date of Measurements: 2-16-87

<u>Well Identification</u>	<u>Top of Casing Elevation Above M.S.L.</u>	<u>Distance to Water Level</u>	<u>Elevation of Groundwater Above M.S.L.</u>
MW1	50.02	7.76	42.26
MW2	49.70	7.19	42.51
MW3	51.43	29.17	22.26
MW4	48.70	6.44	42.26
MW5	49.49	6.68	42.81
MW6	51.29	8.5	42.79
MW7	50.33	7.27	43.06

Date of Measurements: 3-3-87

<u>Well Identification</u>	<u>Top of Casing Elevation Above M.S.L.</u>	<u>Distance to Water Level</u>	<u>Elevation of Groundwater Above M.S.L.</u>
MW1	50.02	7.15	42.87
MW2	49.70	6.39	43.31
MW3	51.43	27.97	23.46
MW4	48.70	5.67	43.03
MW5	49.49	5.86	43.63
MW6	51.29	7.73	43.56
MW7	50.33	6.41	43.92

001109

Date of Measurements: 3-22-87

<u>Well Identification</u>	<u>Top of Casing Elevation Above M.S.L.</u>	<u>Distance to Water Level</u>	<u>Elevation of Groundwater Above M.S.L.</u>
MW1	50.02	7.42	42.59
MW2	49.70	6.74	42.96
MW3	51.43	3.82	47.61
MW4	48.70	6.09	42.61
MW5	49.49	5.79	43.70
MW6	51.29	8.01	43.28
MW7	50.33	6.97	43.36

Date of Measurements: 7-13-87

<u>Well Identification</u>	<u>Top of Casing Elevation Above M.S.L.</u>	<u>Distance to Water Level</u>	<u>Elevation of Groundwater Above M.S.L.</u>
MW1	50.02	7.32	42.70
MW2	49.70	6.47	43.23
MW3	51.43	29.24	22.19
MW4	48.70	5.70	43.00
MW5	49.49	5.92	43.57
MW6	51.29	7.73	43.56
MW7	50.33	6.58	43.75

\* Water level data from the following dates have been plotted on maps: 2-16-87 (Figure 5-3), 3-3-87 (Figure 5-4), 3-22-87 (Figure 5-5), 7-13-87 (Figure 5-6). Data from 2-5-87 has not been plotted because of missing data from MW-1.

\*\* Monitor Well MW-3 penetrates the intermediate water-bearing zone, while all other wells penetrate the uppermost water-bearing unit.

001110

## Appendix E-2 Hydraulic Conductivity

Falling head tests were performed on the six wells penetrating the uppermost aquifer and one well completed in the intermediate water-bearing zone and the data used to calculate the hydraulic conductivity (K). The Bouwer and Rice (1976) method was used in determining hydraulic conductivities. The geometry and symbols of a well in an unconfined aquifer are shown in Figure 1. The curve relating coefficient C to  $1/r_w$  is shown in Figure 2.

When depth (D) equals H (height of the well) in a well that completely penetrates the aquifer, the following equation is used:

$$\ln R_e/r_w = \left( \frac{1.1}{\ln (H/r_w)} + \frac{C}{L/r_w} \right)^{-1}$$

The parameter "C" in this equation is a function of L (length of screen) divided by  $r_w$  (horizontal distance from well center to original aquifer, including sand pack) and is found using the graph in Figure 2.

Then K (hydraulic conductivity) is calculated from the drop in water level in the well after suddenly introducing a slug of water into the well. The reader should note that this is a modification of the Bouwer and Rice method, where K is calculated from the rise of the water level in the well after suddenly removing a slug of water from the well. The following equation is used:

$$K = \frac{r_c^2 \ln (R_e/r_w)}{2L} \frac{1}{t} \ln \left( \frac{Y_o}{Y_t} \right)$$

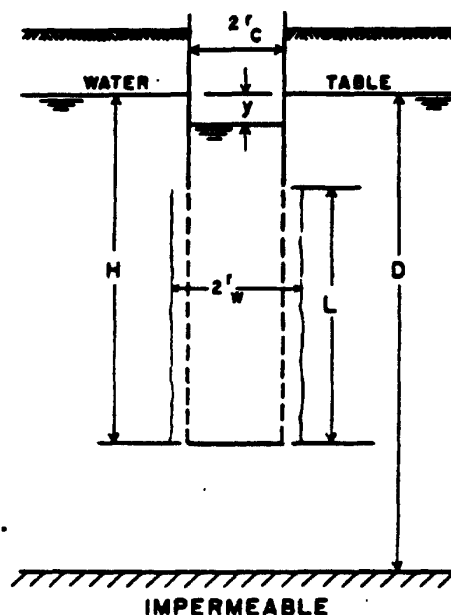
The term  $(1/t) \ln (Y_o/Y_t)$  is obtained from the best fitting straight line in a plot of  $\ln Y$  versus  $t$ . Definitions for other parameters are given in Figure 1.

Calculations for individual wells are on the following pages.

001111



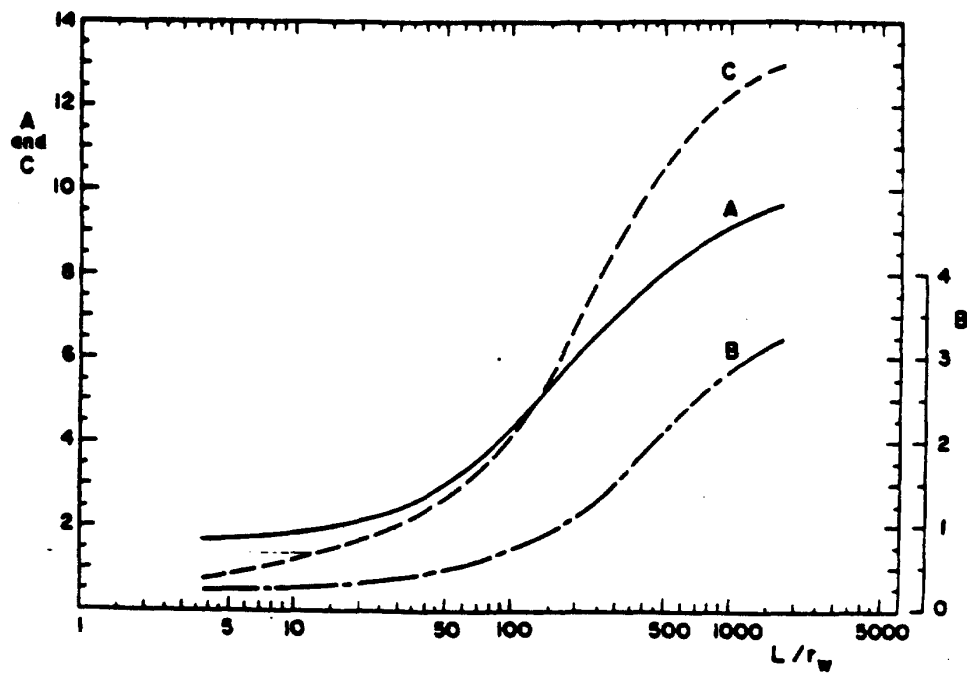
Figure 1. Geometry and symbols of a partially penetrating, partially perforated well casing with gravel pack or developed zone around perforated section (Bouwer and Rice, 1976).



- L Height of screen.
  - $Y_o$  Vertical distance between water level in the well at the start of the test (i.e., the well casing is filled) and static water level in the well.
  - $Y_t$  Vertical distance between water level in the well at a given time during the test and static water level in the well.
  - $R_e$  Effective radius over which  $y$  is dissipated.
  - $r_w$  Horizontal distance from well center to original aquifer, including sand pack.
  - $r_c$  Inside radius of the casing when the water level is above the screen.
  - H Height of water table, assuming the well does not completely penetrate the aquifer.
  - D Depth from bottom of aquifer to the top of the water table.
- (Note: At the ITS site, the wells completely penetrate the aquifer and the screen is set at the bottom of the water-bearing sand. Water production from the overlying clays is negligible. Therefore  $H = D$ .)
- t Time (in seconds)

001112

Figure 2. Curves relating coefficients A, B, and C to  $L/r_w$  (Bouwer and Rice, 1976).



001113

FALLING HEAD TEST DATA  
MONITOR WELL MW-1

Distance from top of casing level to water level : 7.15 ft.  
Amount of "stick-up" casing : 2.5 ft.  
Distance from groundlevel to water level : 4.65 ft.  
Bottom of aquifer and screen : 40 ft.  
Height of water column before start of test : 35.35 ft.

$H = D = 35.36 \text{ ft. (424.32 in.)}$

$r_w = 3 \text{ in.}$

$r_c = 1 \text{ in.}$

$L = 10 \text{ ft. (120 in.)}$

$Y_o = 7.15 \text{ ft (85.8 in.)}$

<u>Time(t)</u>	<u>Water Level from Top of Casing</u>	<u>Height of (<math>Y_t</math>) Water Column</u>
16:22:55	filled	7.15
16:27:55	5.96'	1.19
16:32:55	6.38'	0.77
16:37:55	6.67'	0.48
16:42:55	6.87'	0.28
16:47:55	6.92'	0.23
16:52:55	6.98'	0.17
17:07:55	7.09'	0.06
17:22:55	7.11'	0.04
17:37:55	7.15'	0

001114

FALLING HEAD TEST DATA  
MONITOR WELL MW-2

Distance from top of casing to water level : 6.69 ft.  
Amount of "stick-up" casing : 2 ft.  
Distance from groundlevel to water level : 4.69 ft.  
Bottom of aquifer and screen : 38 ft.  
Height of water column before start of test : 33.31 ft.

$H = D = 33.31 \text{ ft (399.72 in)}$

$r_w = 3 \text{ in.}$

$r_c = 1 \text{ in.}$

$L = 120 \text{ in.}$

$Y_o = 6.69 \text{ ft. (80.28 in)}$

<u>Time(t)</u>	<u>Water Level from Top of Casing</u>	<u>Height of Water Column (<math>Y_t</math>)</u>
11:12:45	filled	6.69
11:13:45	5.46'	1.23
11:14:45	6.03'	0.66
11:15:45	6.22'	0.47
11:16:45	6.42'	0.27
11:17:45	6.53'	0.16
11:18:45	6.57'	0.12
11:21:45	6.61'	0.08
11:22:45	6.63'	0.06
11:23:45	6.65'	0.04
11:29:45	6.65'	0.04
11:44:45	6.69'	0

001115

FALLING HEAD TEST DATA  
MONITOR WELL MW-3

Distance from top of casing to water level : 4.99 ft.  
Amount of "stick-up" casing : 1.5 ft.  
Distance from ground level to water level : 1.54 ft.  
Bottom of aquifer and screen : 94 ft.  
Height of water column before start of test : 92.46 ft.

$H = D = 92.46 \text{ ft (1109.52 in.)}$

$r_w = 3 \text{ in.}$

$r_c = 1 \text{ in.}$

$L = 10 \text{ ft. (120 in.)}$

$Y_o = 4.99 \text{ ft.}$

<u>Time</u>	<u>Water Level from Top of Casing</u>	<u>Height of Water Column (<math>Y_t</math>)</u>
08:55:25	filled	4.99
09:00:25	0.34'	4.65
09:05:25	0.59'	4.40
09:10:25	0.86'	4.13
09:15:25	1.03'	3.96
09:20:25	1.22'	3.77
09:25:25	1.42'	3.57
09:30:25	1.55'	3.44
09:40:25	1.77'	3.22
09:55:25	2.02'	2.97
10:10:25	2.17'	2.82
10:25:25	2.31'	2.68
10:40:25	2.44'	2.55
10:55:25	2.45'	2.54
11:10:25	2.45'	2.54
11:25:25	2.51'	2.48
11:40:25	2.51'	2.48
11:55:25	2.51'	2.48

001116

FALLING HEAD TEST DATA  
MONITOR WELL MW-4

Distance from top of casing to water level : 5.67 ft.  
Amount of "stick-up" casing : 2 ft.  
Distance from ground level to water level : 3.67 ft.  
Bottom of aquifer and screen : 38.5 ft.  
Height of water column before start of test : 34.83 ft.

$H = D = 34.83 \text{ ft. (417.96 in)}$

$r_w = 3 \text{ in.}$

$r_c = 1 \text{ in.}$

$L = 120 \text{ in.}$

$Y_o = 5.125 \text{ ft.}$

<u>Time</u>	<u>Water Level from Top of Casing</u>	<u>Height of Water Column(<math>Y_t</math>)</u>
08:56:55	filled	5.125
09:01:55	4.70'	0.425
09:06:55	5.05'	0.075
09:11:55	5.10'	0.025
09:16:55	5.125'	0

001117

FALLING HEAD TEST DATA  
MONITOR WELL MW-5

Distance from top of casing to water level	: 5.86 ft.
Amount of "stick-up" casing	: 1.5 ft.
Distance from ground level to water level	: 4.36 ft.
Bottom of aquifer and screen	: 38.5 ft.
Height of water column before start of test	: 34.14 ft.

$H = D = 34.14 \text{ ft (409.68 in)}$

$r_w = 3 \text{ in.}$

$r_c = 1 \text{ in.}$

$L = 10 \text{ ft (120 in)}$

$y_o = 5.86 \text{ ft.}$

<u>Time(t)</u>	<u>Water Level from Top of Casing</u>	<u>Height of Water Column(<math>y_t</math>)</u>
10:57:00	filled	5.86
11:02:00	5.30'	0.56
11:07:00	5.63'	0.23
11:12:00	5.71'	0.15
11:17:00	5.72'	0.14
11:22:00	5.76'	0.10
11:27:00	5.77'	0.09
11:42:00	5.79'	0.07
11:57:00	5.79'	0.07
12:12:00	5.80'	0.06
12:27:00	5.80'	0.06
12:42:00	5.80'	0.06

001118

FALLING HEAD TEST DATA  
MONITOR WELL MW-6

Distance from top of casing to water level : 7.73 ft.  
Amount of "stack-up" casing : 3.5 ft.  
Distance from ground level to water level : 4.23 ft.  
Bottom of aquifer and screen : 39 ft.  
Height of water column before start of test : 34.77 ft.

$H = D = 34.77 \text{ ft. (417.24 in)}$

$r_w = 3 \text{ in.}$

$r_c = 1 \text{ in.}$

$L = 10 \text{ ft. (120 in.)}$

$Y_o = 8.06 \text{ ft.}$

<u>Time(t)</u>	<u>Water Level from Top of Casing</u>	<u>Height of Water Column(<math>Y_t</math>)</u>
1:13:30	filled	8.06
1:14:30	5.26'	2.8
1:15:30	6.80'	1.26
1:16:30	7.30'	0.76
1:17:30	-	
1:18:30	7.55'	0.51
1:19:30	7.73'	0.33
1:20:30	7.82'	0.24
1:21:30	7.82'	0.24
1:22:30	7.86'	0.2
1:23:30	7.88'	0.18
1:24:30	7.90'	0.16
1:28:30	7.92'	0.14
1:33:30	7.97'	0.09
1:38:30	7.98'	0.08
1:43:30	8.01'	0.05
1:58:30	8.03'	0.03
2:13:30	8.06'	0

001119



FALLING HEAD TEST DATA  
MONITOR WELL MW-7

Distance from top of casing to water level : 6.41 ft.  
Amount of "stick-up" casing : 3.5 ft.  
Distance from ground level to water level : 2.91 ft.  
Bottom of aquifer and screen : 39 ft.  
Height of water column before start of test : 36.09 ft.

$H = D = 36.09 \text{ ft. (433.08 in)}$

$r_w = 3 \text{ in.}$

$r_c = 1 \text{ in.}$

$L = 10 \text{ ft. (120 in.)}$

$Y_o = 6.51 \text{ ft.}$

<u>Time(t)</u>	<u>Water Level from Top of Casing</u>	<u>Height of Water Column(<math>Y_t</math>)</u>
15:05:30	6.01'*	0.51
15:10:30	6.40'	0.11
15:15:30	6.40'	0.11
15:20:30	6.43'	0.08
15:25:30	6.44'	0.07
15:30:30	6.46'	0.05
15:35:30	6.48'	0.03
15:50:30	6.51'	0

\* Casing filled w/11 gal. instead of to the top.

001120

Hydraulic Conductivity Calculation for  
Monitor Well MW-1

$$\begin{aligned}
 \ln R_e/r_w &= \left( \frac{1.1}{\ln (H/r_w)} + \frac{C}{L/r_w} \right)^{-1} \\
 &= \left( \frac{1.1}{\ln (424.32 \text{ in}/3 \text{ in})} + \frac{2.45}{120 \text{ in}/3 \text{ in}} \right)^{-1} \\
 &= (0.222 + 0.061)^{-1} \\
 &= (0.283)^{-1} \\
 &= 3.53
 \end{aligned}$$

$$\begin{aligned}
 K &= \frac{r_c^2 \ln (R_e/r_w)}{2L} \frac{1}{t} \ln \frac{Y_o}{Y_t} \\
 &= \frac{(1 \text{ in})^2 * 3.53}{2(120 \text{ in})} \frac{1}{300 \text{ sec}} \ln \frac{85.8 \text{ in}}{14.29 \text{ in}} \\
 &= 0.0147 * 0.006 \text{ in/sec} \\
 &= 8.8 * 10^{-5} \text{ in/sec} \\
 &= 8.8 * 10^{-5} \text{ in/sec} * \frac{1 \text{ ft}}{12 \text{ in}} * \frac{3600 \text{ sec}}{\text{hour}} * \frac{24 \text{ hr}}{\text{day}} \\
 &= 0.632 \text{ ft/day}
 \end{aligned}$$

Note: K is expressed as an absolute value in this and following calculations, rather than a negative value, which occurs as a result of test and equation modifications.

001121

Hydraulic Conductivity Calculation for  
Monitor Well MW-2

$$\begin{aligned}
 \ln R_e/r_w &= \left( \frac{1.1}{\ln(H/r_w)} + \frac{C}{L/r_w} \right)^{-1} \\
 &= \left( \frac{1.1}{\ln(399.72 \text{ in}/3 \text{ in})} + \frac{2.45}{120 \text{ in}/3 \text{ in}} \right)^{-1} \\
 &= (0.2249 + 0.061)^{-1} \\
 &= (0.2859)^{-1} \\
 &= 3.498
 \end{aligned}$$

$$\begin{aligned}
 K &= \frac{r_c^2 \ln(R_e/r_w)}{2L} \frac{1}{t} \ln \left( \frac{Y_o}{Y_t} \right) \\
 &= \frac{(1 \text{ in})^2 * 3.498}{2 (120 \text{ in})} \frac{1}{120} \ln \frac{80.28 \text{ in}}{7.92 \text{ in}} \\
 &= 0.0146 * 0.0193 \text{ in/sec} \\
 &= 2.82 * 10^{-4} \text{ in/sec} \\
 &= 2.82 * 10^{-4} * \frac{1 \text{ ft}}{12 \text{ in}} * \frac{3600 \text{ sec}}{\text{hour}} * \frac{24 \text{ hr}}{\text{day}} \\
 &= 2.030 \text{ ft/day}
 \end{aligned}$$

001122

Hydraulic Conductivity Calculation for  
Monitor Well MW-3

$$\begin{aligned}
 \ln R_e/r_w &= \left( \frac{1.1}{\ln (H/r_w)} + \frac{C}{L/r_w} \right)^{-1} \\
 &= \left( \frac{1.1}{\ln (1109.5 \text{ in}/3 \text{ in})} + \frac{2.45}{120 \text{ in}/3 \text{ in}} \right)^{-1} \\
 &= (0.186 + 0.061)^{-1} \\
 &= (0.247)^{-1} \\
 &= 4.049
 \end{aligned}$$

$$\begin{aligned}
 K &= \frac{r_c^2}{2L} \ln (R_e/r_w) \frac{1}{t} \ln \left( \frac{y_o}{y_t} \right) \\
 &= \frac{(1 \text{ in})^2}{240 \text{ in.}} \frac{4.049}{300} \ln \frac{59.88 \text{ in}}{55.8 \text{ in.}} \\
 &= .0169 * 0.00024 \text{ in/sec} \\
 &= 4.056 \times 10^{-6} \\
 &= 4.056 * 10^{-6} * \frac{1 \text{ ft}}{12 \text{ in}} * \frac{3600 \text{ sec}}{\text{hr}} * \frac{24 \text{ hr}}{\text{day}} \\
 &= 0.0292 \text{ ft/day}
 \end{aligned}$$

001123

Hydraulic Conductivity Calculation for  
Monitor Well MW-4

$$\begin{aligned}
 \ln R_e/r_w &= \left( \frac{1.1}{\ln (H/r_w)} + \frac{C}{L/r_w} \right)^{-1} \\
 &= \left( \frac{1.1}{\ln (417.96 \text{ in}/3 \text{ in})} + \frac{2.45}{120 \text{ in}/3 \text{ in}} \right)^{-1} \\
 &= (0.2228 + 0.061)^{-1} \\
 &= (0.2838)^{-1} \\
 &= 3.52
 \end{aligned}$$

$$\begin{aligned}
 K &= \frac{r_c^2 \ln (R_e/r_w)}{2L} \frac{1}{t} \ln \left( \frac{Y_o}{Y_t} \right) \\
 &= \frac{1 \text{ in} * 3.52}{2 (120 \text{ in})} \frac{1}{300 \text{ sec}} \ln \frac{61.5 \text{ in}}{5.1 \text{ in}} \\
 &= 0.0147 * 0.0083 \text{ in/sec} \\
 &= 1.22 * 10^{-4} \text{ in/sec} \\
 &= 1.22 * 10^{-4} * \frac{1 \text{ ft}}{12 \text{ in}} * \frac{3600 \text{ sec}}{1 \text{ hr}} * \frac{24 \text{ hr}}{\text{day}} \\
 &= 0.878 \text{ ft/day}
 \end{aligned}$$

001124

Hydraulic Conductivity Calculation for  
Monitor Well MW-5

$$\begin{aligned}
 \ln R_e/r_w &= \left( \frac{1.1}{\ln (H/r_w)} + \frac{C}{L/r_w} \right)^{-1} \\
 &= \left( \frac{1.1}{\ln (409.68 \text{ in}/3 \text{ in})} + \frac{2.45}{120 \text{ in}/3 \text{ in}} \right)^{-1} \\
 &= (0.2237 + 0.061)^{-1} \\
 &= (0.2847)^{-1} \\
 &= 3.51
 \end{aligned}$$

$$\begin{aligned}
 K &= \frac{r_c^2 \ln (R_e/r_w)}{2L} \frac{1}{t} \ln \left( \frac{Y_o}{Y_t} \right) \\
 &= \frac{1 \text{ in} * 3.51}{2 (120 \text{ in})} \frac{1}{300 \text{ sec}} \ln \frac{70.32 \text{ in}}{6.72 \text{ in}} \\
 &= 0.0146 * 0.0078 \text{ in/sec} \\
 &= 1.14 * 10^{-4} \text{ in/sec} \\
 &= 1.14 * 10^{-4} * \frac{1 \text{ ft}}{12 \text{ in}} * \frac{3600 \text{ sec}}{1 \text{ hr}} * \frac{24 \text{ hr}}{\text{day}} \\
 &= 0.8208 \text{ ft/day}
 \end{aligned}$$

001125

Hydraulic Conductivity Calculations for  
Monitor Well MW-6

$$\begin{aligned}
 \ln R_e/r_w &= \left( \frac{1.1}{\ln (H/r_w)} + \frac{C}{L/r_w} \right)^{-1} \\
 &= \left( \frac{1.1}{\ln (417.24 \text{ in}/3 \text{ in})} + \frac{2.45}{120 \text{ in}/3 \text{ in}} \right)^{-1} \\
 &= (0.223 + 0.061)^{-1} \\
 &= (0.284)^{-1} \\
 &= 3.52
 \end{aligned}$$

$$\begin{aligned}
 K &= \frac{r_c^2 \ln (R_e/r_w)}{2L} \frac{1}{t} \ln \left( \frac{Y_o}{Y_t} \right) \\
 &= \frac{1 \text{ in} * 3.52}{2 (120 \text{ in})} \frac{1}{120 \text{ sec}} \ln \frac{96.72 \text{ in}}{15.12 \text{ in}} \\
 &= 0.0147 * 0.0155 \text{ in/sec} \\
 &= 2.279 * 10^{-4} \text{ in/sec} \\
 &= 2.279 * 10^{-4} \text{ in/sec} * \frac{1 \text{ ft}}{12 \text{ in}} * \frac{3600 \text{ sec}}{1 \text{ hr}} * \frac{24 \text{ hr}}{\text{day}} \\
 &= 1.64 \text{ ft/day}
 \end{aligned}$$

001126

Hydraulic Conductivity Calculations for  
Monitor Well MW-7

$$\begin{aligned}
 \ln R_e/r_w &= \left( \frac{1.1}{\ln(H/r_w)} + \frac{C}{L/r_w} \right)^{-1} \\
 &= \left( \frac{1.1}{\ln(433.08\text{in}/3\text{in})} + \frac{2.45}{120\text{ in}/3\text{ in}} \right)^{-1} \\
 &= (0.221 + 0.061)^{-1} \\
 &= (0.282)^{-1} \\
 &= 3.55
 \end{aligned}$$

$$\begin{aligned}
 K &= \frac{r_c^2 \ln(R_e/r_w)}{2L} * \frac{1}{t} * \ln \left( \frac{Y_o}{Y_t} \right) \\
 &= \frac{1\text{ in} * 3.55}{2(120\text{in})} \frac{1}{300\text{ sec}} \ln \frac{78.12\text{ in}}{1.32\text{ in}} \\
 &= 0.0148 * 0.0136\text{ in/sec} \\
 &= 2.01 * 10^{-4}\text{ in/sec} \\
 &= 2.01 * 10^{-4}\text{ in/sec} * \frac{1\text{ ft}}{12\text{in}} * \frac{3600\text{ sec}}{1\text{ hr}} * \frac{24\text{ hr}}{\text{day}} \\
 &= 1.45\text{ ft/day}
 \end{aligned}$$

001127



Appendix E-3  
Summary of Monitor Well MW-3  
Work Activities

Monitor Well MW-3 was completed February 3, 1987 in a formation composed of unconsolidated fine sand, silt, and clay. Table 4-6 documents well completion specifications.

Static water levels and sediment levels are recorded in Table 1.

After development of the well, it was bailed and sampled for the first time. TCE values were 26 ppm. A falling head test was then run on this well, in which the casing was filled to the top with city tap water and the decrease in head measured periodically. It was observed that static water level measurements were in the range of 24.9 to 26.4 feet below ground surface.

After the second falling head test (March 13, 1987) static water level did not return to its typical level, but stayed at 0.99 feet below ground level.

At the start of the second round of bailing and sampling on March 22, 1987, it was observed that static water level still had not returned to the range of original values, being at 0.3 feet below the ground level. A value of 2 ppm TCE was reported for this second sample.

The sediment level at the bottom of the well at this time was measured at 86 feet below ground level, indicating that the well had "silted in" nearly the entire length of the screen, from 84 to 94 feet.

The solution to this problem was to flush the silt and clay out the wellbore and develop the well again by compressed air. A total of six 55 gallon drums of water were produced from MW-3 on April 15, 1987. Ideally, the water produced at the end is more clear and free of fine sediment than that at the beginning of the development. In this case, the water still contained fine sediment that will continue to "silt in" the wellbore.

After development, sediment levels were measured at 92.3 feet on April 20, 1987, indicating all but 1.7 feet of the screen was open and freely admitting formation water. Static water level measured 25.75 feet, within the range of original values. After bailing on April 27, 1987, at which static water level was 25.18 feet below ground surface and sediment levels at 92.3 feet, a third sample was collected and analyzed at 0.02 ppm TCE.

Water level measurements taken April 30, 1987 showed a static water level of 25.78 feet and sediment levels of 83.6 feet, indicating that the well had "silted in", completely plugging the screened interval.

001128

Table 1  
Static Water Level and Sediment Level Measurements  
for MW-3

<u>Date</u>	<u>Type of Measurement</u>	<u>Depth to Static Water Level</u>	<u>Depth to Sediment Level</u>
2-5-87	Development	26.4' below grd level	-
2-16-87	Bailing/Sampling #1	25.67' below grd level	-
3-3-87	Falling Head Test	24.97' below grd level	-
3-13-87	Falling Head Test	0.99' below grd level	-
3-22-87	Bailing/Sampling #2	0.3' below grd level	86' below grd level
4-14-87	Measurement	-	84' below grd level
4-20-87	Measurement	25.75' below grd level	92.3' below grd level
4-27-87	Bailing/Sampling #3	25.18' below grd level	92.3' below grd level
4-30-87	Measurement	25.78' below grd level	83.6' below grd level
7-13-87	Measurement	25.74' below grd level	84.89' below brd level

001129

Appendix F-1  
Cleanup Criteria

001130

## CALCULATION OF CANCER RISK ASSOCIATED WITH TCE - INGESTION

Note: Original Calculation and assumptions provided by EPA Region 6.

### References:

1. Endangerment Assessment, Mid-South Wood Products Site, Mena, Arkansas, CH2M Hill, Chapter 5, May 1985.
2. Remedial Investigation Report, Bayou Bonfouch Site, Louisiana, CH2M Hill, April 1986.
3. Health Effects Assessment for Trichloroethene, U.S. EPA, Environmental Criteria and Assessment Office, Cincinnati, Ohio, September, 1984.
4. Kimbrough, R.D., et al., Health Immigrations of 2, 3, 7, 8 (TCDD) Contamination of Residential Soil, Journal of Toxicology and Environmental Health, 14: 47-93, 1984.

### Assumptions:

1. Land use continues as industrial or light commercial.
2. Average lifetime soil ingestion rate for a 70 kg man, over a 40 year period of a 70 year lifetime is 0.00082 g/kg body weight/day.
3. Total fraction of worker exposure time is 0.34, based on 250 work days per year, outdoors 50% of work time.
4. Cancer Potency for TCE is  $2.2 \times 10^{-2}$  kg-day/mg.
5. Target area level is  $10^{-6}$  excess cancer risk.

### Equations:

d = cif  
p = cancer potency  
c = contaminant concentration  
i = average lifetime soil ingestion rate  
f = total fraction of exposure time  
R = risk = pd

001131

Calculations:

A) Compute cancer risk for a TCE concentration of 150 mg/kg.

$$d = \text{cif}$$

$$= \left(150 \frac{\text{mg}}{\text{kg}}\right) \times 0.00082 \times 0.34 \times 10^{-3}$$

$$= 4.18 \times 10^{-5} \frac{\text{mg}}{\text{kg-day}}$$

$$pd = 4.18 \times 10^{-5} \frac{\text{mg}}{\text{kg-day}} \times 2.2 \times 10^{-2} \frac{\text{kg-day}}{\text{mg}}$$

Risk =  $9.20 \times 10^{-7}$  or less than 1 out of 1,000,000  
are at excess risk of cancer from ingestion of TCE.

B) Compute soil concentration associated with  $1 \times 10^{-6}$  excess cancer risk.

$$d = X (0.00082) (0.34 \times 10^{-3}) = (2.78 \times 10^{-7}) X$$

$$pd = (2.2 \times 10^{-2}) (2.78 \times 10^{-7}) X = (6.13 \times 10^{-9}) X$$

$$1 \times 10^{-6} = (6.13 \times 10^{-9}) X$$

$$X = 161 \text{ mg/kg}$$

001132

# CALCULATION OF CANCER RISK ASSOCIATED WITH PCBs - INGESTION

Note: Original Calculation and assumptions provided by EPA Region 6.

## References:

1. Superfund Public Health Evaluation Manual, U.S. EPA, Office of Emergency and Remedial Response, Washington, D.C., October, 1986.
2. Versar. Draft Exposure Factor Handbook Prepared for EPA, September, 1987.
3. Updated Reference Dose and Cancer Potency Numbers for Risk Assessments, U.S. EPA, Memorandum from Sandra Lee, Regional Support Team for Toxics Integration Branch, Washington, D.C., November 16, 1987.

## Assumptions:

1. Land use continues as industrial or light commercial.
2. Average lifetime soil ingestion rate for a 70 kg man, over a 40 year period of a 70 year lifetime is 0.00082 g/kg body weight/day.
3. Total fraction of worker exposure time is 0.34, based on 250 work days per year, outdoors 50% of work time.
4. Cancer potency for PCBs is  $7 \times 10^0$  (mg PCBs/kg body-weight/day)<sup>-1</sup> (EPA, 1987).
5. Target area level is  $10^{-6}$  excess cancer risk.

## Calculations:

a) Compute cancer risk for a PCB concentrations of 350 mg/kg.

$$d = cif = (350 \text{ mg/kg}) (0.00082) (0.34 \times 10^{-3}) = 9.76 \times 10^{-5} \frac{\text{mg}}{\text{kg-day}}$$

$$R = pd = (7 \times 10^0) (9.76 \times 10^{-5}) = 6.83 \times 10^{-4} \text{ or approximately 1 out of 1500 are at excess risk of cancer from ingestion of PCBs in the soil.}$$

001133

CALCULATION OF CANCER RISK ASSOCIATED WITH COMBINED EFFECT OF TCE  
INHALATION AND INGESTION

References:

1. Farmer, W.J., M-S Yang, J. Letey, and W.F. Spencer. Land Disposal of Hexachlorobenzene Wastes: Controlling Vapor Movement in Soils. U.S. EPA-600/2-80-119, 1980.
2. U.S. EPA. Superfund Exposure Assessment Manual. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, OSWER Directive 9285.5-1, 1986.
3. California Department of Health Services. California Site Mitigation Decision Tree. Toxic Substances Control Division, Sacramento, Ca., May, 1986.

Assumptions:

1. Air-filled soil porosity was equivalent to total soil porosity; this simulated conditions of dry soil maximizing the permeability of organic vapors through soil.
2. Depth of soil cover was assumed to be 1 centimeter; a thin soil cover results in an increased emission rate. This assumption was based on data that TCE was present in soil borings from 0 to 12 inches, and the actual depth of soil cover was not known.
3. Airborne concentrations of TCE were estimated using the Industrial Source Complex - Long Term model.
4. Maximum ground level concentrations fall 10 meters downwind from the edge of the contaminated area.
5. Soil cleanup level based on the cancer risk posed by soil ingestion, and inhalation of vapor emitted from soil.
6. Risk associated with the inhalation of TCE vapors was estimated using the unit risk value of  $1.3 \times 10^{-6} (\text{ug}/\text{m}^3)^{-1}$ .

001134

Calculations:

A) Calculate emission rate from soil.

$$E = D \frac{(P_A)^{10/3}}{P_T^2} \left( \frac{CS}{L(1 \times 10^9)} \right) A$$

$$= (0.08606) (0.55)^{1.33} \left( \frac{(4.02 \times 10^{-4}) (0.01)}{(1) (1 \times 10^9)} \right) (9.85 \times 10^6)$$

$$= 1.54 \times 10^{-9} \text{ g/s} / 9.85 \times 10^6 \text{ cm}^2$$

E = emission rate

D = diffusion coefficient

P<sub>A</sub> = air-filled soil porosity

P<sub>T</sub> = total soil porosity

C = saturation vapor concentration

S = soil concentration

L = depth of soil cover

A = surface area of landfill

B) Calculate saturation vapor concentration of TCE

$$C_{si} = P \frac{MW_i}{RT}$$

$$= \frac{(57.9) (131)}{62.3 (303^\circ)} = 0.402 \frac{\text{g}}{\text{L}} \frac{1\text{L}}{1000 \text{ cm}^3} = 4.02 \times 10^{-4} \frac{\text{g}}{\text{cm}^3}$$

C<sub>si</sub> = saturation vapor concentration

P = 57.9 mmHg

MW<sub>i</sub> = 131 g/mole

R = 62.3 L - mmHg/K/mole

T = 303°K

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C) Estimation of Airborne Concentrations (TCE)

<u>Soil Core</u>	<u>Emission Rate</u>	<u>Maximum Receptor Annual-Average GLC</u>
0.001 mg/kg	$1.54 \times 10^{-10}$ g/total area/s	$4.0 \times 10^{-7}$ ug/m <sup>3</sup>
0.01	$1.54 \times 10^{-9}$	$4.0 \times 10^{-6}$
0.1	$1.54 \times 10^{-8}$	$4.0 \times 10^{-5}$
1.0	$1.54 \times 10^{-7}$	$4.0 \times 10^{-4}$
10	$1.54 \times 10^{-6}$	$4.0 \times 10^{-3}$
100	$1.54 \times 10^{-5}$	$4.0 \times 10^{-2}$
1000	$1.54 \times 10^{-4}$	$4.0 \times 10^{-1}$
10000	$1.54 \times 10^{-3}$	$4.0 \times 10^0$

$$\text{Ground Level Concentrations} = \text{Soil Concentration} * 4 \times 10^{-4}$$

D) Determination of a cleanup level in soil - accounting for soil ingestion and inhalation of vapors emitted from soils:

$$1 \times 10^{-6} = \frac{1.3 \times 10^{-6}}{\text{ug/m}^3} (X \text{ mg/kg}) (4.02 \times 10^{-4}) (0.34) +$$

$$\frac{2.2 \times 10^{-2}}{\text{mg/kg/day}} \frac{(X \text{ mg/kg}) (5.7 \times 10^{-5} \text{ kg/day}) (0.34)}{70 \text{ kg}}$$

$$1 \times 10^{-6} = 1.78 \times 10^{-10} (X \text{ mg/kg}) + 6.09 \times 10^{-9} (X \text{ mg/kg})$$

$$1 \times 10^{-6} = 6.27 \times 10^{-9} (X \text{ mg/kg})$$

$$X = 160 \text{ mg/kg}$$

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